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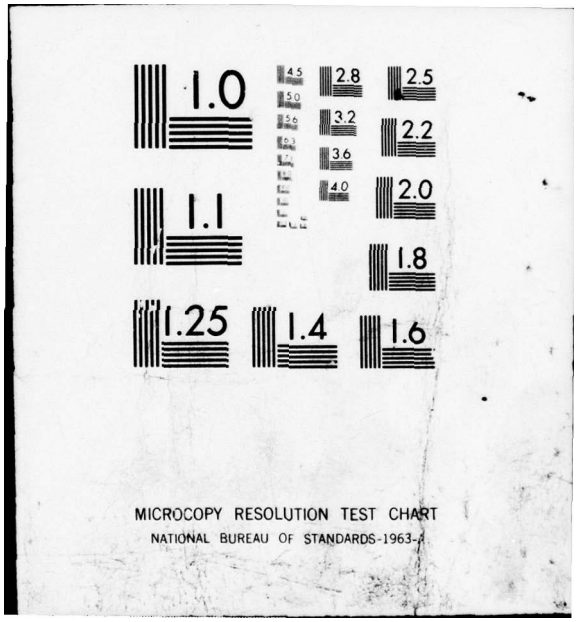
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LEVEL II

(1)

SUSQUEHANNA RIVER BASIN

PINE GROVE DAM

COMMONWEALTH OF PENNSYLVANIA

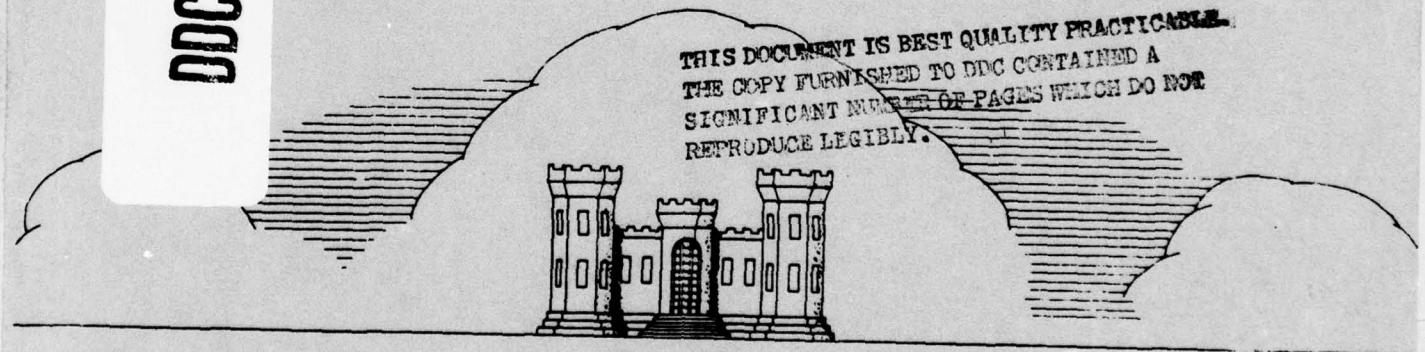
CHESTER & LANCASTER COUNTIES

INVENTORY NUMBER NDS PA-23

PHASE I INSPECTION REPORT

NATIONAL DAM INSPECTION PROGRAM

DACW31-78-C-0044



Prepared For
DEPARTMENT OF THE ARMY
Baltimore District, Corps of Engineers
Baltimore, Maryland

by

BERGER ASSOCIATES, INC
CONSULTING ENGINEERS
HARRISBURG, PA

AUGUST 1978

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(6) National Dam Inspection Program. Pine Grove Dam (NDS PA-23), Susquehanna River Basin, Chester and Lancaster Counties, Pennsylvania. Phase 1 Inspection Report.

PHASE I REPORT
NATIONAL DAM INSPECTION PROGRAM

(12) 66p.

Name of Dam: PINE GROVE DAM

State & State Number: PENNSYLVANIA - 15-281

County Located: CHESTER & LANCASTER

Stream: OCTORARO CREEK

Date of Inspection: July 13, 1978 (11) 25 Aug 78

Based on a visual inspection, past performance and available engineering data, the dam and its appurtenances appear to be in very good condition.

The spillway capacity and available reservoir storage are sufficient to pass the Probable Maximum Flood (PMF), as defined in the Corps of Engineers guidelines, without overtopping the dam. (15) DACW31-78-C-0044

The following recommendations are presented for action by the owner:

1. That the seepage condition continue to be monitored on the schedule as now in effect. If changes in flow or if turbidity is noted, an engineering evaluation should be made immediately, and if conditions dictate, remedial action should be taken.

2. That the outlet channel from the outlet structure be extended to meet the natural stream.

3. That the control valve in the outlet structure be operated at least once each year to insure drawdown capability in case of an emergency.

4. That a formal surveillance and downstream warning system be developed to be used during periods of high precipitation.

SUBMITTED BY:

BERGER ASSOCIATES, INC.
HARRISBURG, PENNSYLVANIA

DATE: August 25, 1978

COMMONWEALTH OF PENNSYLVANIA
PROFESSIONAL ENGINEER
RODNEY VINCENT HOUSEAL
No. 4756-E

Rodney V. Houseal

APPROVED BY:

John H. Kenworthy

JOHN H. KENWORTHY
LTC, Corps of Engineers
Acting District Engineer

DATE: 25 Aug 78

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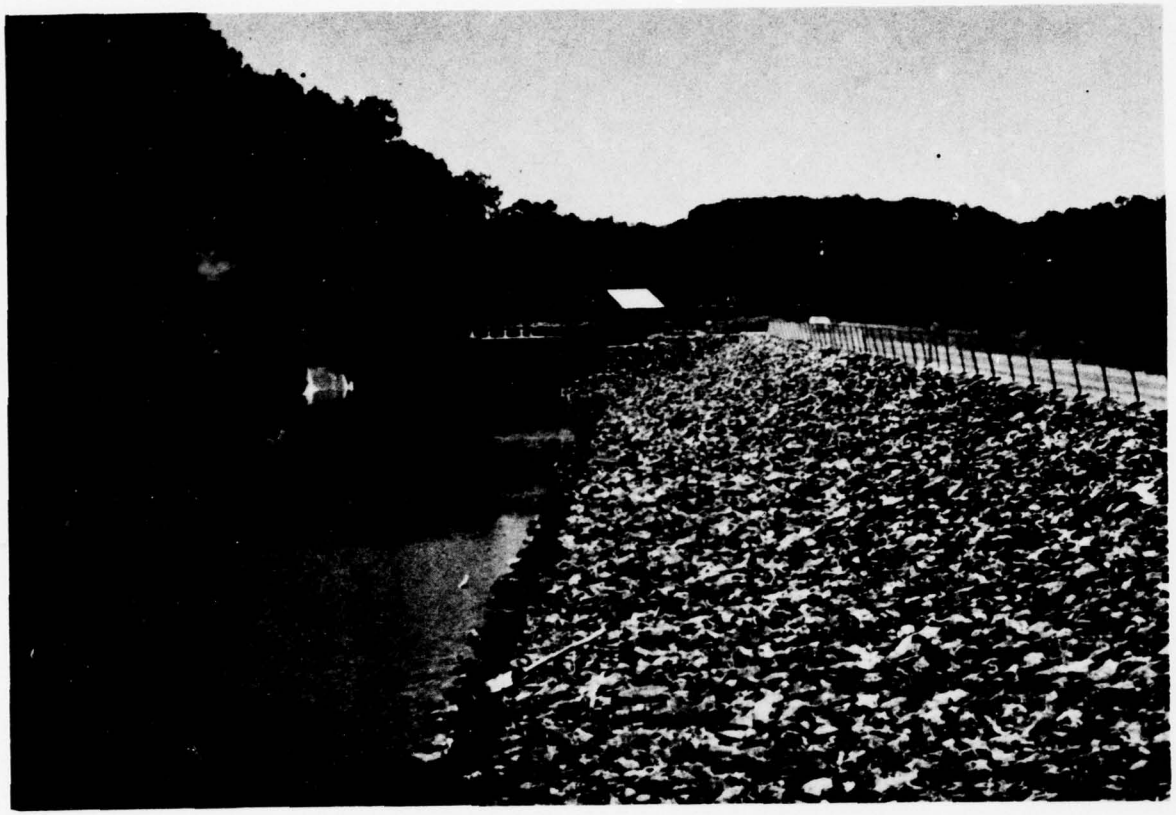


OVERVIEW

SECTION 1 - PROJECT INFORMATION

1.1 GENERAL

A. Authority

The Dam Inspection Act, Public Law 92-367, authorized the Secretary of the Army, through the Corps of Engineers, to initiate a program of inspections of dams throughout the United States. The Phase I Inspection and Report is limited to a review of available data, a visual inspection of the dam site and the basic calculations to determine the hydraulic adequacy of the spillway.

B. Purpose

The purpose is to determine if the dam constitutes a hazard to human life and property.

1.2 DESCRIPTION OF PROJECT

A. Dam and Appurtenances

Pine Grove dam is located on Octoraro Creek about 3 miles east of the town of Oxford, Pa. The dam impounds 2.5 billion gallons (7,660 acre-feet) of water at the normal pool elevation of 280, and is a primary source of water for the Chester Water Authority, which serves the City of Chester, Pennsylvania. Chester Water Authority's 45 mgd Octoraro Treatment Plant and Pumping Station is located a short distance downstream of the dam. The drainage area upstream of the dam is 131 square miles. The reservoir covers 669 acres, or slightly more than one square mile, at the normal pool elevation of 280. Octoraro Creek discharges into the Susquehanna River about 12 miles downstream of the dam.

The dam is a 630-foot-long earth and rockfill structure with a maximum height of 65 feet above streambed, and was built in the late 1940's. The downstream slope of the dam is 4H to 1V and the upstream slope is 3H to 1V below elevation 285 and 2.5H to 1V above elevation 285. A steel sheet pile cutoff wall was driven through the foundation overburden to rock for most of the length of the dam. A typical dam section is shown in Appendix D, Plate IX.

The spillway for the dam consists of an uncontrolled concrete ogee 71.5 feet long and a gate structure with 2 Tainter gates, each 44 feet wide by 30 feet high.

B. Location: Little Britain Township, Lancaster County and Lower Oxford Township, Chester County U.S. Quadrangle, Kirkwood, Pennsylvania Latitude 39°47.9', Longitude 76°02.6' (Appendix D, Plates I & II)

C. Size Classification: Intermediate (65 feet high)

D. Hazard Classification: Significant (See Section 3.1.E)

E. Ownership: Chester Water Authority
Fifth & Welsh Streets
Chester, Pennsylvania 19016

F. Purpose of Dam: Water Supply

G. Design and Construction History

The project was designed by Albright & Friel, Inc. of Philadelphia, Pennsylvania, and a permit was issued on August 13, 1947 for its construction. The contract for construction of the dam was awarded to George M. Brewster and Son, Inc., Bogota, New Jersey and the contract for the construction and installation of the Tainter gates was awarded to the American Bridge Company of Philadelphia, Pennsylvania. Construction was begun in the spring of 1948 and completed by the end of 1949.

The construction was under the control of the design engineer. A resident engineer was on the project. PennDER memorandums indicate good control of the project during construction.

H. Normal Operating Procedures

The dam has been constructed and is used for domestic water supply for the City of Chester, Pennsylvania. Water is supplied to the treatment plant just downstream from the dam through a system of four 36-inch intake sluice gates and 54 and 42-inch outlet pipes. An uncontrolled concrete ogee spillway and two 30-foot high Tainter gates control the water level in the reservoir. The operation schedule requires raising the Tainter gates when the flow over the spillway crest is 30 inches. The Tainter gates are operated by electric motors. In the event of power failure, there is a standby propane backup generator and if necessary, the gates can be operated manually. One 54-inch gate and discharge pipe is also available as a blowoff.

1.3 PERTINENT DATA

A. Drainage Area (square miles)

Computed for this report (Original design used 139.6)	131

B. Discharge at Dam Site (cubic feet per second)
See Appendix B for hydraulic calculations.

Maximum known flood, August 1942, estimated on basis of record for USGS gaging station at Rising Sun, Md.	25,000
Maximum flood since construction of dam, June 23, 1972	17,100
Warm water outlet at pool Elev. 276	110
Outlet works low-pool outlet at pool Elev. 246	45
Outlet works at pool level Elev.280 (spillway crest)	140
Spillway capacity, gates open, pool Elev. 300 (top of dam)	107,300
Spillway capacity, gates closed, pool Elev.300 (top of dam)	55,100

C. Elevation (feet above mean sea level)

Top of dam	300
Spillway crest	280
Sill of Tainter Gates	250
Top of Tainter Gates	280.17
Upstream portal invert of outlet pipe	241
Downstream portal invert of outlet pipe	240.74
Streambed at centerline of dam	238
Maximum tailwater about	250

D. Reservoir (miles)

Length of maximum pool	6.5
Length of normal pool	3.9

E. Storage (acre-feet)

Spillway crest (Elev. 280)	7,660
Top of dam (Elev. 300)	27,800

F. Reservoir Surface (acres)

Top of dam (Elev. 300)	1,400
Spillway crest (Elev. 280)	669

G. Dam

The design drawings indicate an embankment with a crest width of 20 feet and a top elevation of 300.0 feet. The upstream and downstream slopes are 2.5H to 1V from the top of the embankment, elevation 300 to elevation 285 then 3H to 1V to the bottom of the slope. The entire upstream slope is protected with 3 feet of dumped rock over an 18-inch gravel bedding. The downstream slope is composed of dumped rock fill and at present has a grass cover. The main portion of the embankment is constructed of impervious fill. Refer to Appendix D, Plate IX for typical section.

H. Outlet Facilities

The intake tower is a portion of the right wall of the approach channel to the Tainter gates. It is fitted with four 3 feet by 5 feet sluice gates which take water directly from the approach channel. Their invert elevations are: 241, 251, 261 and 271. A gate valve, with invert at elevation 241, releases water from the intake tower to a 54-inch cast iron pipe which passes under the dam embankment. The 54-inch outlet pipe is 260 feet long and terminates in a 30-inch gate valve which releases the water to Octoraro Creek via a short ditch and Tweed Creek.

Water is delivered to the treatment plant by means of two 42-inch cast iron pipes which leave the 54-inch pipe about 40 feet upstream from its end.

The 30-inch waste valve on a 54-inch by 30-inch reducer has not been opened in about 9 years. Management feels it is not needed since the Tainter gates can draw the pool down to elevation 250 - only eleven feet above the invert of the outlet pipe.

I. Spillway

Type: An uncontrolled standard-type ogee weir and two Tainter gates.

Length: The weir has a length of 71.5 feet.
Each Tainter gate is 44 feet wide.

Crest elevation:

Weir	280
Top of each Tainter gate	280.17
Sill of each Tainter gate	250

Upstream channel: The two Tainter gates and the ungated spillway all receive water from a channel about 170 feet long by 97 feet wide and about 32 feet deep at normal pool stages. The channel is excavated in rock and is unpaved.

Downstream channels:

Weir: The chute downstream from the weir is excavated in rock and is very rough. It is about 300 feet long and about 110 feet wide. There appears to be no energy dissipation problem since the Tainter gates take the larger portion of flood waters.

Tainter gates: The chute downstream from the two Tainter gates is lined with concrete. It is about 120 feet long and 105 feet wide. It terminates in an unlined stilling pool measuring 200 feet by 200 feet by about 10 feet deep. The stilling pool is not very effective and the bank on the opposite side of the receiving creek is extensively eroded.

J. Regulating Outlets

The available flow is taken by pipe for domestic use in Chester, Pennsylvania.

SECTION 2 - ENGINEERING DATA

2.1 DESIGN

A. Data Available

1. Hydrology and Hydraulics

A 1947 design report submitted to the Commonwealth by Albright and Friel, Inc. summarized hydrologic and hydraulic calculations in support of the design. The report includes a mass diagram, flow duration curve, reservoir area and capacity curve and spillway discharge and capacity curves. This report is in the PennDER files.

2. Embankment

The data available on the embankment is contained in correspondence referencing the material being used during the construction of the dam. There are no design calculations relative to slope stability.

3. Appurtenant Structures

The data available for review regarding the spillway, Tainter gates, intake and outlet structures are limited to the design drawings in the PennDER files.

B. Design Features

1. Embankment

The dam embankment is composed of two zones of materials: 1) The center and upstream portion is rolled impervious fill, 2) The downstream portion is composed of dumped rockfill. A two-foot thick run of bank stones filler is located between the two zones and extends along the foundation of the embankment to the rock toe on the downstream side. Sheet piling was driven through the natural overburden to refusal and extends up into the embankment as a cutoff. Refer to Appendix D, Plate IX for typical design section.

The upstream and downstream embankment slopes vary with 2.5H to 1V above elevation 285 and 3H to 1V below elevation 285.

The upstream slope cover consists of 3 feet of dumped riprap over an 18-inch gravel bedding. The downstream slope cover, in the design drawings, was the exposed dumped rock fill (this slope actually has a vegetation cover at the present time).

The top of dam is elevation 300 which is 65 feet above the original streambed.

2. Appurtenant Structures

a. Intake Tower

This structure is a reinforced concrete housing about 80 feet upstream from the centerline of the dam adjacent to the right wall of the spillway approach channel. Four ports or openings are provided in the side of this structure. The inverts of these openings are at elevation 241, 251, 261 and 271. A 54-inch cast-iron supply line leads from the tower to the toe of the embankment where it is reduced to a 42-inch pipe which leads to the downstream filter plant. The controls for the intake are mounted on the top of the structure and are exposed. A 54-inch sluice gate controls the flow into the supply line. An emergency outlet is provided through a valve box where the 54-inch pipe reduces to the 42-inch supply line. This box has a short outlet channel and does not outlet entirely to the natural stream. Refer to Appendix D, Plate VII, for plan view and pipe layout.

A concrete ramp provides access to the intake tower from the breast of the dam.

b. Spillway

The spillway for this dam consists of the spillway approach channel, an uncontrolled concrete ogee spillway, and two mechanically operated Tainter gates.

The approach channel is excavated in rock. The uncontrolled spillway is 71-feet 6-inches in length. The two Tainter gates are 44 feet wide each and have a height of 30 feet. The gates are operated by electric motors. A standby backup generator is available in the gate control house for emergency use. The gates can be operated manually if needed.

The spillway crest is at elevation 280. Refer to Appendix D, Plates III, IV, V, VII, X and XI for photographs and design drawings of these features.

C. Design Data

1. Hydrology and Hydraulics

The hydrologic and hydraulic analysis available from PennDER for Octoraro Dam was reasonably complete. The original spillway design flood (inflow) was 60,000 cfs. This was calculated as 250 percent

of the August 1942 flood as recorded at the USGS gaging station at Rising Sun, Maryland, and after adjustment for the difference in drainage area. It was also calculated to be equal to 5,000 times the square root of the drainage area. The original design provided for the two Tainter gates and an uncontrolled weir 150 feet long. Construction problems necessitated the later reduction of the length of the weir to the present length of 71.5 feet.

2. Embankment

There are no design calculations or criteria in the PennDER files. Reference is made in the PennDER correspondence to the designer regarding the need for testing of the borrow soil materials. The correspondence lists tests for: "Angle of internal friction, cohesion, coefficient of permeability, plastic limit, liquid limit, shrinkage limit and grain sizing". Correspondence discussing the results of some of the tests, between PennDER and the design engineer are in the file. It is doubtful that the result of these tests could have been used in the design since the date of request for test information was May, 1949, and the construction was begun in the spring of 1948 and completed prior to December 14, 1949.

Test boring and test pit information is available in the files. Refer to Appendix D, Plate VIII, for test boring sections and information.

A 1976 inspection report prepared by Justin and Courtney, Inc. contains considerable information regarding the capacity and structural stability of the dam. A copy of this report was obtained from the owner.

3. Appurtenant Structures

The design information relative to the uncontrolled spillway, the Tainter gates and the intake structure are limited to the hydraulic phase of the design. Structural information is obtained from the plans but no calculations are available for review in the files.

2.2 CONSTRUCTION

Construction inspection reports by PennDER are in the file from March 31, 1949 through September 30, 1949. These data include progress information and the status of each major division of work. The reports indicate that the embankment was constructed under proper control and good workmanship was exercised.

Although there is no record of the exact starting or completion date, the available information indicates that the project began in the spring of 1948 and completed in the fall of 1949.

2.3 OPERATION

The operation of this facility is concerned primarily with the supply of water to the treatment plant just downstream from the dam. Information pertinent to the dam indicates that the Tainter gates are put into operation when the depth of discharge over the uncontrolled spillway reaches 30 inches. Other records relate to the level of withdrawal through the intake tower and the volume withdrawn. These records are available at the treatment plant.

2.4 EVALUATION

A. Availability

A complete set of design drawings are available in the PennDER files. These data contain details of the project structural units as well as pertinent information regarding hydrology and hydraulics. A 1976 inspection report prepared by Justin and Courtney, Inc. includes recent test boring information, laboratory soil test data, and slope stability studies.

B. Adequacy

1. Hydrology and Hydraulics

The hydrologic and hydraulic information available in the PennDER files is reasonably complete. The available data are sufficient to make an assessment of the capacity of this facility.

2. Embankment

The design drawings, together with the 1976 inspection report are sufficient for making a judgment on the condition and stability of the embankment.

3. Appurtenant Structures

The design drawings are the only available file information regarding the spillway, Tainter gates and the intake and outlet structure. These data combined with the hydraulic information permit a reasonable assessment of their capacity.

C. Operating Records

The construction and operating records in the PennDER files indicate considerable concern over the persistent seepage problem at the downstream toe of the embankment.

The storm of record since the dam was completed in 1949 was the 1972 tropical storm Agnes. At this time, the owner's representative indicated the discharge over the uncontrolled spillway crest was 58 inches. The Tainter gates were both opened 6 feet during this event.

The post construction period regarding the seepage is recorded in a considerable number of reports which tabulate the readings over a "V" notch weir located beyond the downstream toe. The daily readings were discontinued in March 1954 when PennDER, together with the owners engineering consultant were satisfied that the seepage flow was stabilized. Records are still being kept of this condition (July, 1978), and are available from the owner.

D. Post Construction Changes

Although some changes regarding the location and size of the spillway were made during design, there are no records of any post construction changes to this project.

E. Seismic Stability

The dam is located in Seismic Zone 1 and it is considered that the static stability with normal safety factors is sufficient to withstand minor earthquake induced dynamic forces. No calculations or studies have been made to confirm this.

SECTION 3 - VISUAL INSPECTION

3.1 FINDINGS

A. General

The general outward appearance of the dam and its appurtenant structures is very good. The single item of concern is the long term seepage condition at the downstream toe of the embankment.

On the owner's decision, the engineering firm of Justin and Courtney was engaged to inspect this dam and prepare a report of their findings. This inspection was carried out during August and September, 1976. A copy of this report was made available as a source of information for this inspection.

B. Dam

The embankment of this facility shows no signs of cracking, sloughing or settlement. The dumped riprap on the upstream slope is reasonably level and is in good condition. The top of the dam has a stoned surface and is fenced on both sides. The fence post foundations are partially exposed and the fence is tilting. The top is used as a roadway and provides access to the spillway, intake tower and Tainter gate controls. The downstream slope is covered with closely cropped grass and weeds. Dumped rock fill underlies this cover.

A persistent seepage condition was observed at the downstream toe of the embankment. Tall grass and weeds grow in this otherwise closely mowed area. The wet area is well defined by the tall growth of grass, weeds and reeds. Three piezometers are installed at the toe of the slope. Refer to Sketch #1 in Appendix A for plan of locations. A "V" notch weir is located in the wet area for the purpose of measuring the seepage volume. The water was flowing at 1-inch over the weir at the time of this inspection. Seepage was not detected on any portion of the slope.

The abutments of the embankment appeared to be sound with no evidence of distress.

C. Appurtenant Structures

1. Spillway

The spillway is an uncontrolled concrete ogee section. Appendix D, Plate IV. The condition of the spillway is good. The spillway is at an angle of 80° with the axis of the dam. The left

abutment is tied into the natural rock and appears sound. The right abutment joins the left abutment of the Tainter gate structure and is also in good condition.

The spillway channel is excavated into the natural rock formation. The discharge meanders over the irregular rock surface. The cascading of the flow provides for energy dissipation of the discharge. There is no stilling basin. Refer to Appendix D, Plate V. Access to the right abutment of the spillway is directly from the top of the embankment. There is no bridge across the uncontrolled spillway or the spillway outlet channel.

The downstream spillway outlet channel has been heavily eroded as a result of the 1972 tropical storm Agnes and other high discharge storms. Repairs to the dam side of the channel have been made and plans for additional protection of this condition are being considered by the owner.

2. Tainter Gates

Two 44 feet wide by 30 feet high Tainter gates are located between the uncontrolled spillway and the left abutment of the embankment. The gates are operated by electrical power with a propane fueled engine as a standby power source. The gates can also be operated manually. Refer to Appendix D, Plates VI and V. Each gate was operated for observation at the time of this inpsection. The total installation of the gate and controls is in good condition.

3. Intake and Outlet Structures

The intake structure is a concrete vault with exposed manual controls mounted on the deck. The controls are mechanical lifts. There are four controls each operating a 36-inch by 60-inch sluice gate located at four different elevations. The water is admitted into the intake chamber through these gates. The control of flow from the intake chamber is a 54-inch sluice gate which admits the flow into a 54-inch C.I. pipe which is encased in concrete. The discharge from the tower goes directly to the treatment plant located downstream from the dam. An outlet structure is situated downstream from the dam and is connected directly to the 54-inch outlet pipe from the intake tower. The outlet is a concrete valve box. Information obtained from the owner's representative indicates that this outlet has not been used for at least the past nine years. It can be used for drawdown of the reservoir if necessary. The owner's representative stated that this outlet is not used because the reservoir can be drawn down faster by use of the Tainter gates to an elevation of 250. Because this valve has not been operated over a long period, they prefer not to try it. Access to the intake structure is directly from the embankment. There is no bridge. Refer to Appendix D, Plate VII.

The intake control gates are operated on at least a weekly basis depending upon the selection of water level intake. Inspections inside the tower indicated good condition and good maintenance.

The outlet structure channel does not provide a positive outlet to the creek. It stops about 75 feet downstream from the outlet structure. This condition should be improved.

D. Reservoir Area

The reservoir area consists of woodland to the edge of the lake. Recreation access is provided by the owner. There is no reported sedimentation problem. It was reported that the operation of the Tainter gates eliminates any sediment accumulation.

E. Downstream Channel

The water discharging through the spillway has to make a sharp (90°) bend directly below the dam. Heavy erosion has occurred at the opposite hillside as a result of the 1972 tropical storm Agnes and other high runoff storms. Some repairs are being considered to improve this condition. A covered roadway bridge and a low dam cross the stream at a distance of about 1,500 feet below the dam. Aside from the treatment plant there are no residents along or in the flood plain for the next 10 miles. A developing mobile home area is located 10 miles from the dam. This area is adjacent to the stream in its flood plain and is subject to flooding and at the time of this inspection contained five mobile home units. It is expected that the additional loss of life due to dam failure after overtopping would be limited to a few and the additional economical loss would be appreciable. The hazard classification for this dam is considered to be "Significant".

3.2 EVALUATION

The outward appearance of this dam is very good. The inlet structure and Tainter gates are in good operating condition and are well maintained. The spillway is also in good condition.

The embankment slopes are uniform and show no signs of distress. The fencing on the top of the dam needs some attention but this has no bearing on the satisfactory operation of the dam.

The seepage condition at the downstream toe of the embankment has a long history. Records of the problem are in the PennDER file and with the owner. The information available from the files and the 1976 report prepared by Justin and Courtney are discussed further in Section 6 of this report.

The overall evaluation of the dam, with the seepage condition considered, is very good.

SECTION 4 - OPERATIONAL PROCEDURES

4.1 PROCEDURES

This dam is operated as a water supply source for the City of Chester, Pennsylvania. The water is taken from the reservoir through the intake structure and conveyed to the treatment plant downstream from the dam through a 42-inch diameter pipe. Five control gates are located on the tower. Four regulate the elevation of the intake and one controls the flow from the intake to the plant.

The Tainter gates are put into operation when the discharge over the uncontrolled spillway exceeds 30 inches.

The intake gates are operated manually. The Tainter gates are operated mechanically with electric power with a backup propane power source in case of electricity failure. They can also be operated manually.

4.2 MAINTENANCE OF DAM

The maintenance of the dam consists of control of the growth on the downstream slope and the service and care of the inlet control and Tainter gates. The downstream slope is in good condition. The upstream slope is also in good condition. Daily records are kept of the seepage from the downstream toe, as well as the volume of water taken from the reservoir for water supply. Tests are made for turbidity in seepage water on a weekly basis. The water levels in the piezometers are reported also on a weekly basis. Refer to Appendix E for typical operating and monitoring records.

4.3 MAINTENANCE OF OPERATING FACILITIES

The care and maintenance of the intake controls and the Tainter gates is very good. The outlet structure channel is not totally satisfactory as it does not outlet to the creek.

4.4 WARNING SYSTEM

There is no formal warning system in effect. The treatment plant is located about 1500 feet downstream from the dam and is manned 24 hours a day.

4.5 EVALUATION

The dam is well maintained and operated. The only concern regarding the operation of this facility is the outlet structure channel. This channel should be extended to the creek and the valve in the structure should be operated on a regular schedule to insure the drawdown capability in case of emergencies. A downstream warning system should also be developed for emergency situations.

SECTION 5 - HYDROLOGY/HYDRAULICS

5.1 EVALUATION OF FEATURES

A. Design Data

The hydrologic and hydraulic analysis available from PennDER for Octoraro Dam was reasonably complete. The original spillway design flood (inflow) was 60,000 cfs. This was calculated as 250 percent of the August 1942 flood as recorded at the USGS gaging station at Rising Run, Maryland, and after adjustment for the difference in drainage area. It was also calculated to be equal to 5,000 times the square root of the drainage area. The original design provided for the two Tainter gates and an uncontrolled weir 150 feet long. Construction problems necessitated the later reduction of the length of the weir to the present length of 71.5 feet.

B. Experience Data

In the period that the dam has been in operation, from 1951 to the present, the maximum flood was that of June 23, 1972, when the flow was about 17,100 cfs (Appendix B). The spillway passed that flood without distress.

The maximum known flood prior to construction of the dam occurred in August, 1942, when the flow was about 25,000 cfs.

C. Visual Observations

On the date of the inspection, no conditions were observed that would indicate that the appurtenant structures of the dam could not operate satisfactorily during a flood event.

D. Overtopping Potential

This dam has a size classification of "Intermediate" (65 feet high and 27,800 acre-feet of storage) and a hazard potential classification of "Significant" (Chester, Pa. domestic water filtration plant, 0.4 mile downstream and a five-unit mobile home court ten miles downstream).

The Recommended Spillway Design Flood (SDF) for a dam with the above classifications is in the range between one-half the Probable Maximum Flood (PMF) and the PMF. The PMF peak flow for this site is 121,000 cfs (See Appendix B) and the spillway capacity at top-of-dam level is 107,300 cfs or 89 percent of the PMF peak flow.

An estimate of the storage effect of the reservoir shows Octoraro Reservoir does have the storage available that is necessary to pass the PMF without overtopping (See Appendix B), assuming the gates to be fully open.

E. Spillway Adequacy

The spillway capacity is considered to be adequate as the project will pass the PMF without overtopping the dam.

The hydraulic calculations made for this report have considered the possibility that the gates might become inoperative.

The following table gives the results:

Summary of Overtopping Potential

	PMF	1/2 PMF
Gates Up		
Pool Elev. 300	Will Pass	Will Pass
Gates down		
Pool Elev. 300	Overtop	Will Pass

The hydrologic analysis for this investigation was based upon existing conditions of the watershed. The effects of future development were not considered.

F. Additional Recent Hydrology Report

See Appendix B for a summary of the contents of a recent report on Pine Grove Dam by the firm of Justin & Courtney, Inc.

SECTION 6 - STRUCTURAL STABILITY

6.1 EVALUATION OF STRUCTURAL STABILITY

A. Visual Observations

1. Embankment

Other than the long term seepage condition at the downstream toe of the embankment, there are no visual signs that would indicate that the embankment is unstable.

2. Appurtenant Structures

The spillway, Tainter gates and intake structure all appear to be in good condition. The outlet structure channel should be continued downstream until it meets the natural stream.

B. Design and Construction Data

1. Embankment

The most pertinent information regarding the stability of the embankment is contained in the 1976 inspection report prepared by Justin and Courtney, Inc. This report deals in detail with the seepage condition at the downstream slope and concludes that the embankment has an adequate factor of safety against slope failure. Soil test data include the results of triaxial compression tests, consolidation tests, standard moisture density tests and grain size analyses. Test boring logs are also a part of this report.

Other conclusions from this report are: that, "the embankment is dense and well compacted"; that "most of the seepage is occurring through the soil zone just above the rock, rather than through the embankment"; and that, "the present seepage condition is not detrimental to the integrity of the dam". It was also concluded that monitoring of the seepage flow should be continued noting any changes in volume or clarity of the seepage.

This inspection did not encounter any information or observe any other conditions that would disagree with these conclusions.

2. Appurtenant Structures

All appurtenant structures appear in good physical condition. On the basis of these observations and the details of the design drawings, the spillway, Tainter gates, intake and outlet structures are judged to

be structurally sound. However, no detailed analyses were made for this report. No studies or calculations have been made to confirm the structural adequacy of the Tainter gates and its operating mechanism. The outlet structure channel should be improved.

C. Operating Records

The operating records available in the PennDER files and from the owner deal for the most part with the seepage condition. There have been no serious problems during the life of this dam. The 1972 tropical storm Agnes was passed by the structure although considerable erosion took place downstream just below the dam. The owner is presently engaged in some remedial activity in this general area. Refer to Appendix E for typical records.

D. Post Construction Changes

There have been no modifications to this dam since completion of construction in 1949.

E. Seismic Stability

This dam is located in Seismic Zone 1 and it is considered that the static stability is sufficient to withstand minor earthquake induced dynamic forces. No studies or calculations have been made to confirm this assumption.

SECTION 7 - ASSESSMENT/REMEDIAL MEASURES

7.1 DAM ASSESSMENT

A. Safety

The results of the visual inspection, the examination of data in the files and that obtained from the owner indicate that the Pine Grove Dam is in very good condition. The seepage condition at the downstream toe of the embankment is of concern and should continue to be monitored. If changes in volume are detected or if turbidity appears in the discharge, remedial action should be taken.

B. Adequacy of Information

The information available in the PennDER files and from the owner is sufficient for making a reasonable assessment of this facility.

C. Urgency

The recommendations presented below are of a continuing nature relative to seepage. The others should be acted upon as soon as possible.

D. Necessity for Additional Investigation

There are no indications that would require additional investigations at this time. A recent (1976) inspection was made by the owner's engineering consultant.

7.2 RECOMMENDATIONS

A. Facilities

Recommendations regarding the facilities include two items:

1. That the seepage condition continue to be monitored on the schedule as now in effect. If changes in flow or if turbidity is noted, an engineering assessment should be made immediately and if conditions dictate, remedial action should be taken.

2. That the outlet channel from the outlet control structure be extended to meet the existing stream.

B. Operation and Maintenance Procedures

In order to assure the drawdown capability of this facility, the control gate in the outlet structure should be operated at least once each year. Indications are that it has not been operated for at least nine years.

A formal surveillance and downstream warning system should be implemented to be used during periods of high or prolonged precipitation.

APPENDIX A

VISUAL INSPECTION

CHECK LIST - DAM INSPECTION PROGRAM

PHASE I - VISUAL INSPECTION REPORT

NAD NO. 23

PA. ID # 15-281 NAME OF DAM Pine Grove Dam HAZARD CATEGORY Significant

TYPE OF DAM: Earthfill with sheet piling cutoff

LOCATION: Lower Oxford & Little Britain TOWNSHIP Chester & Lancaster COUNTY, PENNSYLVANIA

INSPECTION DATE 7/13/78 WEATHER Clear - Warm TEMPERATURE 70's - 80's

INSPECTORS: H. Jongsma, R. Houseal
R. Steacy, A. Bartlett
D. Black

Mr. Hugh Hetzer
Mr. Lloyd (Clarence)
Mr. P. K. MacEwen
D.E.R.
Bill Goman

NORMAL POOL ELEVATION: 280 AT TIME OF INSPECTION:

BREAST ELEVATION: 300.0 POOL ELEVATION: 280.50

SPILLWAY ELEVATION: 280 & 280.17 (Gates) TAILWATER ELEVATION:

MAXIMUM RECORDED POOL ELEVATION: Spillway + 5' (285') Tainter gates were opened 6' (Agnes 1972)

GENERAL COMMENTS:

Justin-Courtney made a report December, 1976 (We received a copy).

DAM NO. NAD 23

VISUAL INSPECTION

EMBANKMENT	OBSERVATIONS	REMARKS & RECOMMENDATIONS
A. SURFACE CRACKS	None	
B. UNUSUAL MOVEMENT BEYOND TOE	None	
C. SLOUGHING OR EROSION OF EMBANKMENT OR ABUTMENT SLOPES	None	
D. VERTICAL & HORIZONTAL ALIGNMENT OF CREST	O.K.	
E. RIPRAP FAILURES	None	
F. JUNCTION EMBANKMENT & ABUTMENT OR SPILLWAY	O.K. - Some growth	
G. SEEPAGE	High growing reeds at the toe of the embankment. Water in wet area discharging one inch over the weir.	
H. DRAINS	Filter and toe drain.	
J. GAGES & RECORDER	Staff gage in forebay.	
K. COVER(GROWTH)	Upstream - riprap - level surface good condition Top - stone roadway - fenced on both sides. Downstream - grass closely mowed.	

DAM NO. NAD 23

VISUAL INSPECTION

SPILLWAY	OBSERVATIONS	REMARKS & RECOMMENDATIONS
A. APPROACH CHANNEL	Natural rock face on left approach face. Concrete wall on right also leads to the intake tower. Trash deflector across channel approach. Channel clear. Good condition.	
B. WEIR: Crest Condition Cracks Deterioration Foundation Abutments	Concrete ogee - left abutment. Appears in sound condition. Water flowing over spillway. Left abutment tied into rock, good condition. Right abutment adjacent to Tainter gate wall and in good condition.	
C. DISCHARGE CHANNEL Lining Cracks Stilling Basin	Discharge channel excavated into natural rock Meandering flow through rock and cascading Dissipates energy.	
D. BRIDGE & PIERS	None on spillway. Bridge across tainter gate opening.	
E. GATES & OPERATION EQUIPMENT	Two - Tainter Gates. Operate gates when there is 30" of water going over spillway. Electrical, propane and manual power (gates were operated)	
F. CONTROL & HISTORY		

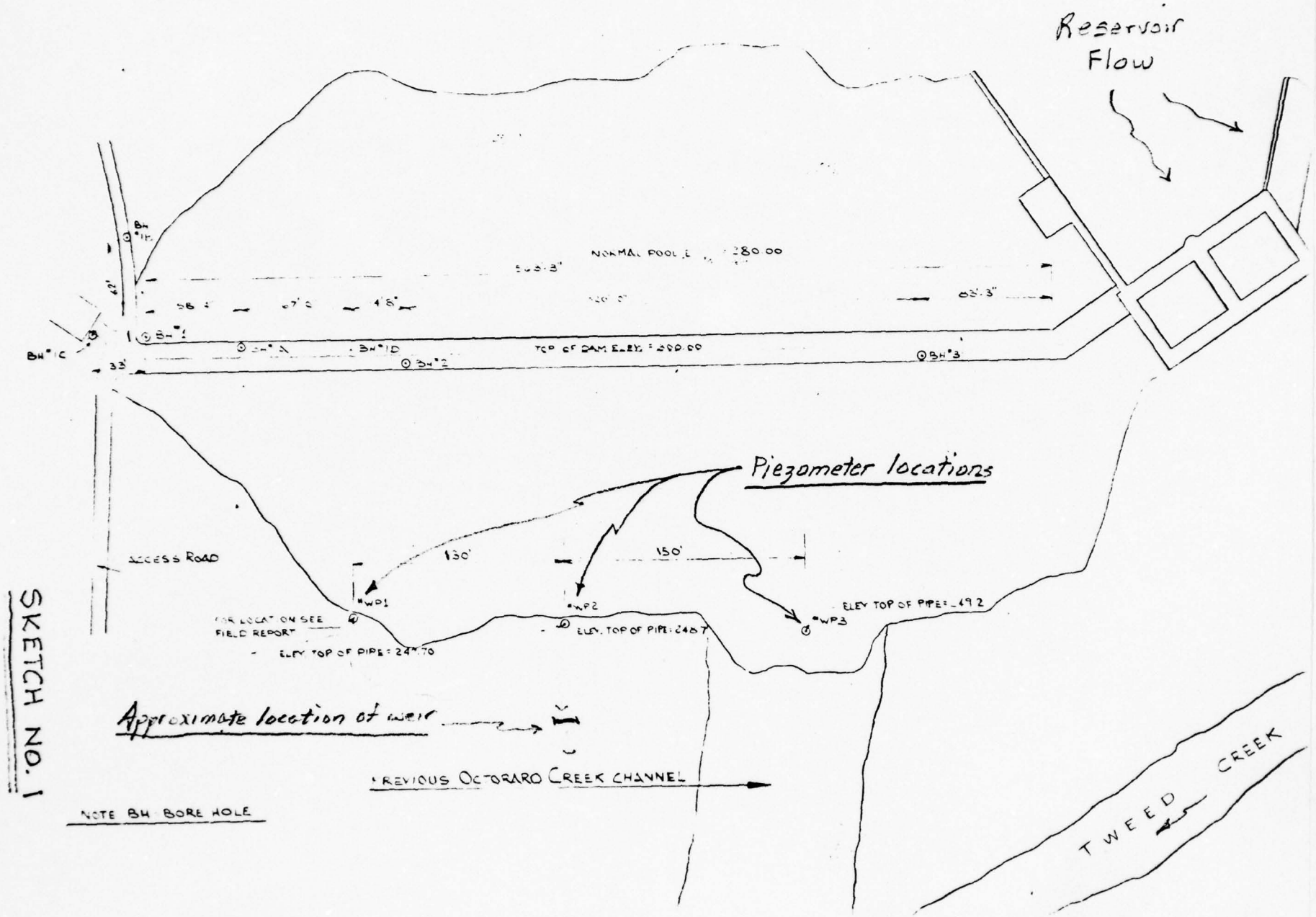
VISUAL INSPECTION

OUTLET WORKS	OBSERVATIONS	REMARKS & RECOMMENDATIONS
A. INTAKE STRUCTURE	Concrete deck with five controls. Staff gage on intake structure. Distribution chamber 54" valve.	
B. OUTLET STRUCTURE	Valve on outlet box never used (at least for past 9 years)	
C. OUTLET CHANNEL	Short and Then 90° curve Opposite side eroded during Agnes.	
D. GATES	4 - 36" x 60" sluice gate (water supply) 1 - 54" sluice gate (blowoff) well greased stems.	
E. EMERGENCY GATE	54" sluice gate	
F. OPERATION & CONTROL	Never used. Not accessible during high water	
G. BRIDGE (ACCESS)	None - direct from left end of dam	

DAM NO. NAD 23

VISUAL INSPECTION

MISCELLANEOUS	OBSERVATIONS	REMARKS & RECOMMENDATIONS
INSTRUMENTATION		
Monumentation		
Observation Wells	None	
Weirs	One located in wet area "V" notch.	
Piezometers	Three at the toe of the embankment	
Other	None	
RESERVOIR		
Slopes	Timber	
Sedimentation	No serious problem. Tainter gates usually handle the accumulation.	
DOWNSTREAM CHANNEL	Heavily eroded at end of spillway channel as a result of Agnes and high flows.	
Condition	Covered Bridge D/S Dist. Small Dam	
Slopes	Forest on left - flood plain then forest on right.	
Approximate Population	Est. 20	
No. Homes	5 Mobile Homes - 10 Miles Treatment Plant	


Reservoir
Flow
NORMAL POOL E
280.00
BH°1C
BH°1
BH°1A
BH°1B
BH°2
TOP OF DAM ELEV. = 288.00
BH°3
33'
ACCESS ROAD
Piezometer locations
130'
150'
°WP1
°WP2
°WP3
FOR LOCATION SEE FIELD REPORT
ELEV TOP OF PIPE = 24.70
ELEV. TOP OF PIPE: 24.87
ELEV TOP OF PIPE = 24.92
Approximate location of weir
PREVIOUS OCTORARO CREEK CHANNEL
TWEED
CREEK
NOTE BH BORE HOLE
SKETCH NO. 1

APPENDIX B

HYDROLOGY/HYDRAULICS

PROJECT Dam Investigation SHEET NO. 1 OF 7

SUBJECT Octoraro Dam ID No. 23

COMPUTED BY RES DATE 7-18-78 CHECKED BY DTR-JJP

Spillway Rating Flood discharge facilities consist of an ungated ogee weir 71.5 ft. wide with a crest elevation at 280' and two Tainter gates each 44' ft. wide and with a top elev of 280.17' ft when closed. The Tainter gate sills are at elev. 250' and when each gate is raised to its upper limit, the bottom of the gate is at elev. 283'. Each opening would then measure 33 ft. by 44 ft. The two Tainter gates and the ungated spillway all receive water from a channel about 170 ft. long by 97' ft. wide with a bottom elev. ranging between 244' and 250'. Top of dam is at elev. 300'.

Pool at 300 ft (top of dam)

Ungated Spillway

$Q = CLH^{3/2}$

$= 4 \times 78 \times (20)^{3/2}$

$= 27,900$ cfs

Crest is standard ogee designed for H = 10'

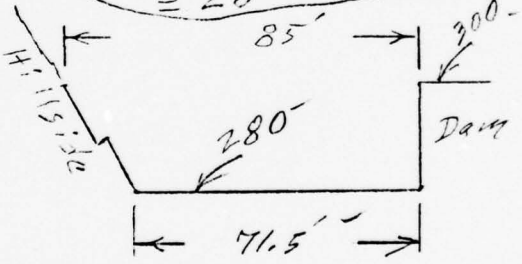
Use C = 3.8 at 10'

4.0 at 20'

C = 4.0'

L = (71.5 + 85) × .5 = 78'

H = 300 − 280 = 20'



Tainter gate Ref "Small Dams" Fig. 197

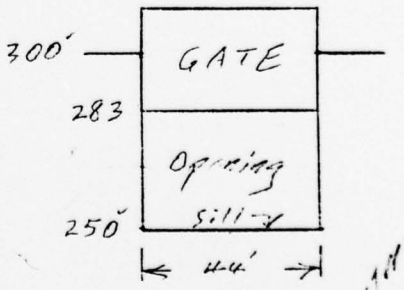
$Q = CA\sqrt{2gh}$ C = 0.60

A = 44 × 33 = 1452

$h = 300 - \frac{250+283}{2} = 33.5$

$Q = 0.60 \times 1452 \times (64.3 \times 33.5)^{1/2}$

$= 40,400$ cfs



Total Capacity = Spillway + Gate #1 + Gate #2

Pool 300 = 27,900 + 40,400 + 40,400 = (108,700 cfs)

PROJECT Dam Investigation SHEET NO. 2 OF ?
SUBJECT Octorara Dam ID No. 23
COMPUTED BY RES DATE 7-18-78 CHECKED BY JJP 7-28-78

Spillway Rating (cont.)

Check approach channel for friction drop.

$V = \frac{1.486}{n} \times r^{2/3} \times S^{1/2}$

$21.8 = \frac{1.486}{0.030} \times (24.9)^{2/3} \times S^{1/2}$

$21.8 = 49.5 \times 8.53 \times S^{1/2}$

$S^{1/2} = \frac{21.8}{49.5 \times 8.53} = 0.0516$

$S = 0.0027$

Fall in 170 ft = 0.46 ft (friction loss)

at Pool Elev 300

Area = $97 \times (300 - 248.5)$
= 4995 sq. ft.

$V = \frac{108,700}{4995} = 21.8$ ft/sec.

$n = 0.030$.

$r = \frac{4995}{98 + 51.5 + 51.5} = 24.9$

Adjusted discharge

Weir $Q = 4 \times 78 \times (20 - 0.46)^{3/2}$
$= 26,900$ cfs.

Tainter Gate
$h = 33.5 - 0.46 = 33.04$
$Q = 0.60 \times 1452 \times (64.3 \times 33.04)^{1/2}$
$= 40,200$

Total
Pool 300

26,900	
40,200	
40,200	
107,300	cfs

Spillway Rating is for some reason gates are all raised.

Pool Elev. 300

Ungated Weir
$Q = 27,900$ cfs (see sheet 1)

Tainter Gate - Flow over top
$Q = CLH^{3/2}$
$= 3.5 \times 44 \times (19.83)^{3/2}$
$= 13,600$ cfs.

Ref: King Fig. 5.2 (b)
$\frac{H}{P} = \frac{20}{33} = 0.606$
$C = 3.5$.
$H = 300 - 280.17 = 19.83$

Total = $27,900 + 13,600 + 13,600 = 55,100$ cfs.
No additional drop in approach

PROJECT Dam Investigation SHEET NO. 3 OF

SUBJECT Octoraro Dam ID No. 7-2

COMPUTED BY RFL DATE 1-28-78 CHECKED BY JJP 1-28-78

Maximum known flood since construction of dam

The flood of June 23 1972 is reported to have caused a head of 58 inches on the weir with both gates opened 6.0 feet.

Weir 58 inches = 4.83 ft

Pool Elev. = 284.83

$L = \frac{4.83}{20.0} \times (85 - 71.5) + 71.5 = 3.26 + 71.5$

$= 74.8$ ft.

$C = 3.8$ at $H = 10$, $\frac{H}{H_o} = \frac{4.83}{10} = .483$

$\frac{C}{C_o} = .91$, $.91 \times 3.8 = 3.46$

$C = 3.46$ Ref. King Fig. 5-27

$Q = CLH^{3/2} = 3.46 \times 74.8 \times (4.83)^{3/2}$

$= 2,750$ cfs

PROJECT Dam Safety Inspection SHEET NO. 4 OF
SUBJECT Ocoee No 2 Dam ID No. 23
COMPUTED BY REG DATE 7-19-78 CHECKED BY JJP 7-28-78

Maximum known flood (cont.)

Tainter Gate Open 6 feet. Pool elev. 284.83

$Q = CA\sqrt{2gh}$ $C = 0.6$ $A = 44 \times 6 = 264$

$h = 284.83 - \frac{250+256}{2} = 31.83$

$Q = .6 \times 264 \times (64.3 \times 31.83)^{1/2} =$

$= 7,166$ cfs

Weir	2,750
Gate 1	7166
Gate 2	7166
Total	17,100 cfs (Assumes no surcharge in reservoir).

The flood of August 1942 produced a flow of 34,500 cfs at USGS gaging station at Ellijay, Ga. (191 sq. mi.) The design engineer estimated that this was equivalent to 25,000 cfs at the dam site.

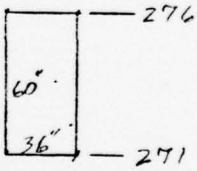
Use 25,000 cfs as max. known flood.

Warm water outlet at pool elev. 276

$Q = C a\sqrt{2gh}$

$= 0.6 \times 3 \times 5 \times (64.3 \times 2.5)^{1/2}$

$= 114$ cfs



30" valve, invert 240.74

$Q = C a\sqrt{2gh} = 0.6 \times \pi \times (1.25)^2 \times \sqrt{64.3 \times (276 - 241.99)}$

$= 2.95 \times (2187)^{1/2} = 137$ cfs

Use 110 cfs.

Outlet works low-pool outlet at pool elev. 284

30" valve, invert 240.74

$Q = C a\sqrt{2gh} = 0.6 \times \pi \times (1.25)^2 \times \sqrt{64.3 \times (246 - 241.99)}$

$= 2.95 \times (258)^{1/2} = 47$ cfs.

Use 47 cfs.

PROJECT Dam Investigation SHEET NO. 5 OF
SUBJECT Ottawa Dam ID No. 23
COMPUTED BY PEL DATE 7-19-78 CHECKED BY JJD 7-28-78

Outlet works at pool level 280 (Spillway crest)
54" dia. C.I. pipe 260' long with 30"
gate valve at outlet to Illinois
Invert elev. 240.74

30" Gate valve orifice

$Q = c\,a\sqrt{2gh}$

$= .6 \times 4.91 \times (64.3 \times 38.01)^{1/2}$

$= 146$ cfs

Use 140 cfs to allow for minor losses and pipe friction.

$c = 0.6$

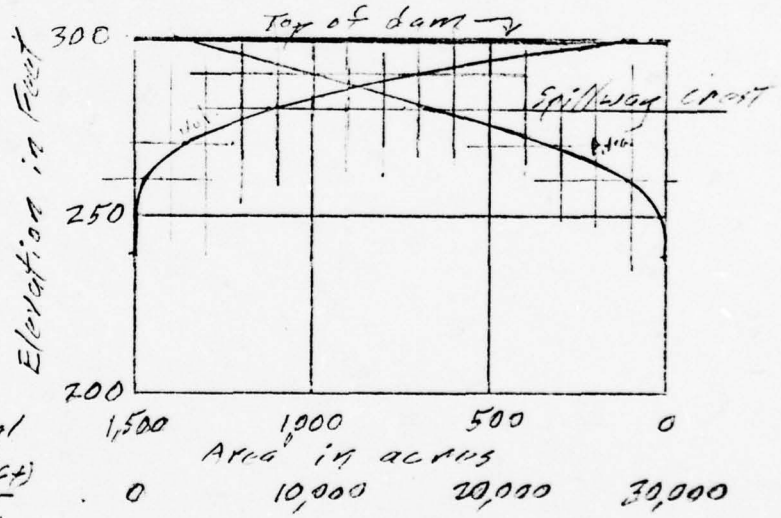
$a = \pi(1.25)^2$

$= 4.91$ sq ft

$h = 280 - (240.74 + 1.25)$

$= 38.01'$

Area - Capacity



Elev.	Area (ac.)	Vol. (ac-ft)	Total Vol. (ac.-ft)
238	0	60	0
250	10	600	60
260	110	2100	660
270	310	4995	2760
280	669	8245	7655
290	980	11875	15,900
300	1395		27,775

PROJECT Dam Investigation SHEET NO. 6 OF
SUBJECT Octoraro Dam ID No. 23
COMPUTED BY RES DATE 7-20-78 CHECKED BY JJP 7-28-78

PMF

Drainage area = 131 sq. mi.

PMF = 920 cfs/sq. mi.

(From relation curve furnished by Baltimore Dist. Corps of Eng.)

PMF = 131 × 920 = 121,000 cfs.

½ PMF = 60,500 cfs.

Overtopping Potential / Gates open Pool at 300

$\frac{\text{Maximum Spillway discharge}}{\text{Peak Inflow}} = \frac{107,300}{121,000}$

$= 0.89$

$\frac{\text{Reg. Resv. Storage}}{\text{Vol. of inflow}} = 0.11$

(From short cut Resv. Routing method furnished by Baltimore Dist. Corps of Engineers)

For volume of inflow assume 26 inches of runoff

Acre ft runoff = 26 × 53.33 × 131

= 182,000 acre ft.

Reg. Resv. Storage = 0.11 × 182,000

= 20,000 acre ft.

Available Storage = 27,775 − 7655

= 20,200 acre ft.

The project can pass the PMF.

Note:- The short cut method would be conservative in this case if the Tainter gates can be opened early in the flood event and thus conserve the available storage for reducing the peak flow.

It follows that project can pass ½ PMF with pool at Elev. 300 and gates open.

PROJECT Dam Investigation SHEET NO. 7 OF 11
SUBJECT Octoraro Dam IV No. 23
COMPUTED BY RES DATE 7-28-78 CHECKED BY JJR 7-31-78

Overtopping Potential (Cont.)
Gates Down - Pool at 300
PMF

$\frac{\text{Maximum spillway discharge}}{\text{Peak inflow}} = \frac{55,100}{121,000} = 0.46$

$\frac{\text{Req. Resv. Storage}}{\text{Vol. of Inflow}} = 0.54$

Req. Resv. Storage = 0.54 × 182,000
= 98,300 acre feet.

Avail. Storage = 20,200 acre feet.

Dam will be overtopped by PMF if gates are left down

Same as above but with ½ PMF

$\frac{\text{Maximum spillway discharge}}{\text{Peak inflow}} = \frac{55,100}{60,300} = 0.91$

$\frac{\text{Req. Resv. Storage}}{\text{Vol. of inflow}} = 0.09$

Req. Resv. Storage = 0.09 × 91,000
= 8,190 acre feet.

Available storage = 20,200

Project will pass ½ PMF with gates down if dam & Gates will stand pool

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Summary of overtopping potential

	PMF	½ PMF
Gates up Pool Elev. 300	will pass	will pass
Gates down Pool Elev. 300	Overtop	will pass

SUMMARY OF HYDROLOGY PORTION OF
RECENT REPORT ON PINE GROVE DAM

Information From Previous Report

Extracts from a recent report to the owner in regard to an investigation of the dam area as follows: (From "Inspection Report - Pine Grove Dam, Octoraro Creek, by Justin and Courtney, Inc., a Division of O'Brien & Gere, Engineers, Inc., dated December, 1976 for Chester Water Authority).

Hydrology

"The spillway design flood for a dam of intermediate height with a significant hazard potential is recommended to be between fifty and one hundred percent of the Probable Maximum Flood. The Probable Maximum Flood (PMF) is the flood discharge that may be expected from the most severe combination of meteorologic and hydrologic conditions that are reasonably possible in the region. There is no frequency associated with the PMF since it is such a rare event beyond reasonable extrapolation from historical records, but a return period on the order of one in ten thousand years is often arbitrarily chosen to represent the frequency of the PMF.

The Susquehanna River Basin Study, published in 1970 by the Susquehanna River Basin Study Coordinating Committee, was used as the basis for developing a unit hydrograph for the project. The PMF and the 100 year flood were calculated from the unit hydrograph and the probable maximum 24 hour precipitation for the area. The PMF for Pine Grove Dam has a peak discharge of 146,000 cubic feet per second and a total flood volume of 172,000 acre-feet. Fifty percent of the PMF has a maximum discharge of 73,000 cfs and a total flood volume of 86,000 acre-feet. The 100 year flood has a peak discharge of 33,100 cfs and a volume of 40,000 acre-feet. The maximum 24 hour precipitation producing these floods is 24.4 inches for the PMF, 12.2 inches for fifty percent of the PMF and 5.6 inches for the 100 year flood.

The PMF, fifty percent of the PMF and the 100 year flood hydrographs were routed through the reservoir with the reservoir at the spillway crest (elevation 280) at the beginning of the storm. The Tainter gates were assumed to be opened when the reservoir reaches elevation 283 and is rising. The gates are then assumed to be opened to the extent necessary to maintain a reservoir elevation of 283 or until the gates fully opened. This is in accordance with the written procedures of the Chester Water Authority for the operation of the Tainter gates during flood time.

From the flood routing calculations it was determined that the PMF cannot be passed without overtopping the dam. However, fifty percent of the PMF can be passed with a maximum rise in the reservoir of fifteen feet above the spillway crest, to elevation 295. The 100 year flood volume of 40,000 acre-feet is less than the volume of the reservoir above the spillway crest, which is 58,000 acre feet, so this flood could be stored in the reservoir and discharged over the concrete spillway without opening the gates.

Improving the project to pass the PMF without overtopping the dam would protect the dam against failure during this event but would do little to protect the treatment plant and other downstream improvements. The PMF peak discharge of 146,000 cfs would only be reduced to about 130,000 cfs after being routed through the reservoir if the dam were raised to contain the PMF. Therefore, downstream damages would be extensive whether or not the dam is improved to pass the PMF without overtopping. It is, therefore, not recommended that modifications be made to the dam or spillway to pass the PMF without overtopping the dam. Since protection against a flood of fifty percent of the PMF is within the recommended guidelines for this project, it is concluded that the Pine Grove spillway provides adequate protection for the dam".

Computations (Appendix B) made for this report indicate that the spillway of the dam, together with the reservoir storage, will pass the PMF, as developed by the Corps of Engineers method, assuming the Tainter gates to be fully open and with no submergence effect from the spillway exit channel and downstream natural channel.

In order to confirm the data presented in the owner's report, an assumed operating procedure must be utilized, together with the detailed routing of the inflow PMF through the reservoir, including exit and downstream channel flow analyses. Such an investigation is beyond the scope of this report and would require additional studies.

As both this report and the owner's report conclude that the spillway can pass 1/2 PMF, and as such capacity is that required by the dam size and hazard classification, the spillway capacity is assumed to be adequate.

Part of the difference in results may be due to the fact that this report uses a drainage area of 131 square miles as planimetered on USGS topo maps. The owner's report used the original designer's drainage area figure of 140 square miles.

APPENDIX C

GEOLOGIC REPORT

GEOLOGIC REPORT

Bedrock - Dam and Reservoir

Formation Name: Peters Creek Schist.

Lithology: The Peters Creek is a fine grained, greenish gray, rather massive, quartzose mica schist. It is composed of feldspar, quartz, mica and chlorite with some magnetite. In addition to the schistosity, two directions of cleavage are usually present.

Structure

The rocks of this area have been folded, faulted and metamorphosed several times in their long history. Bedding is generally obscure, but in the Peters Creek is indicated by the quartz rich layers. Bedding is generally healed and the rock splits along second and third generation cleavage. In this area the strike of these cleavages is generally NE and dips are steep NW to steep SE. The rock is also cut by joints and fractures. Air photo fracture traces trend N50°E, N20°E and N40°W.

Overburden

The bedrock in this area is generally deeply weathered, to form a saprolite averaging 50 feet thick. The saprolite is generally thicker on hilltops and thinner on the slopes. Borings at the dam site indicate from one to twenty feet of saprolite. In the stream valley there was also seven to twelve feet of alluvium.

Aquifer Characteristics

The Peters Creek is composed of essentially impermeable rock. Ground water movement is entirely along fractures and cleavage planes. The rock weathers chiefly through alteration of the feldspars and micas to clay, and oxidation of the magnetite. There are no easily soluble minerals present. The sparolite is quite porous, and can store relatively large volumes of water, but because of the clay content, free movement is impeded.

Discussion

The dam was constructed with an interlocking steel sheet piling

cutoff wall. The piling was driven to refusal, which was probably generally somewhere near the base of the saprolite. Movement through the fractures in the schist below the piling was still possible, and in fact, did occur for some time after the reservoir was filled. The leak gradually diminished with time, probably as the result of clay clogging the fractures. As the bedrock is essentially firm and insoluble, there is little chance of any future increase of leakage along these fractures.

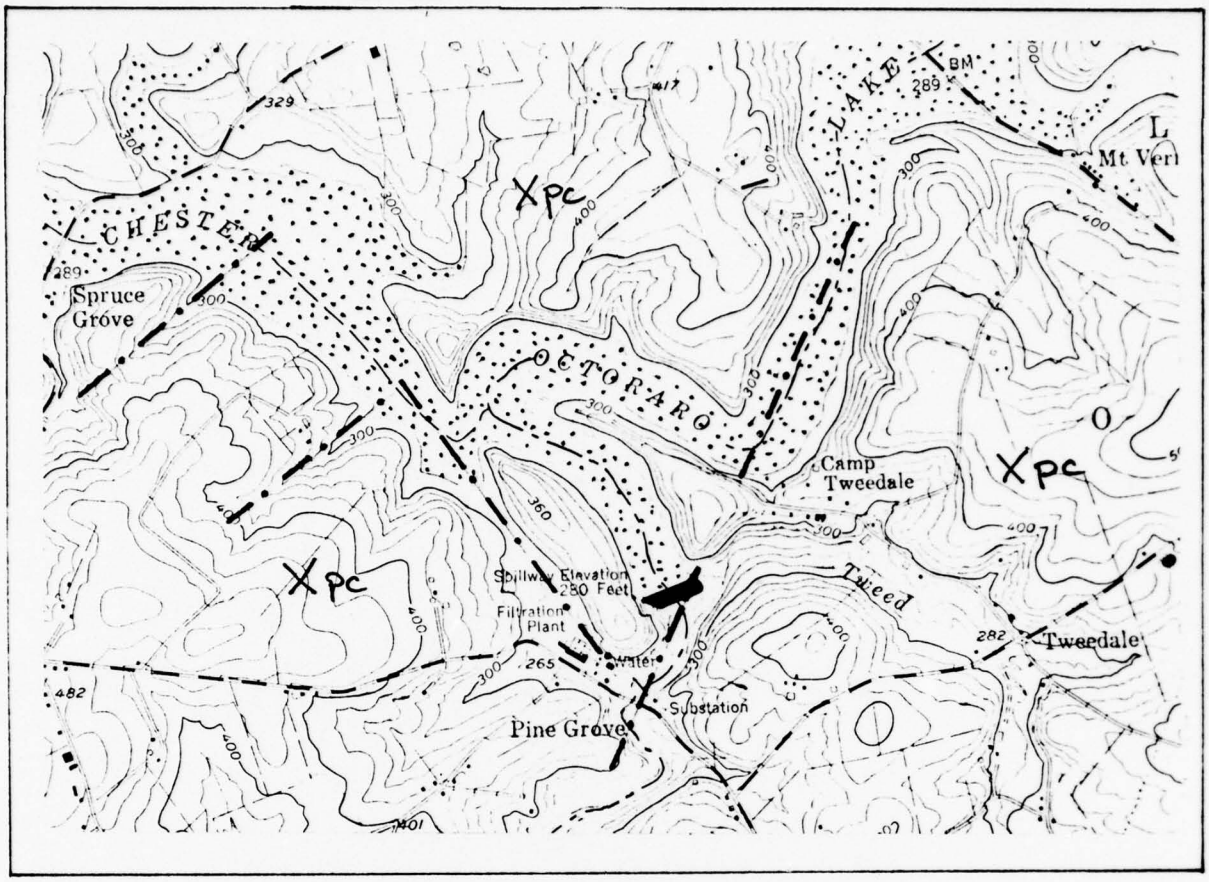
Sources of Information

1. Bascomb, F. and Stose, G.W. (1932) "Coatesville - West Chester Folio, Pa. - Del." U.S. Geological Survey Folio 223.

2. Poth, C.W. (1968) "Hydrology of the Metamorphic and Igneous Rocks of Central Chester County". Pa. Geological Survey Ground Water Report, W-25.

3. Air Photographs, scale 1:24,000 dated - 1969.

4. Records of borings in file.



(Geology from Geologic Map of Pa., 1960)

KEY

Xpc — Peters Creek Schist

— · — · — air photo fracture trace

N

SCALE 1:24000

1 0 1 MILE

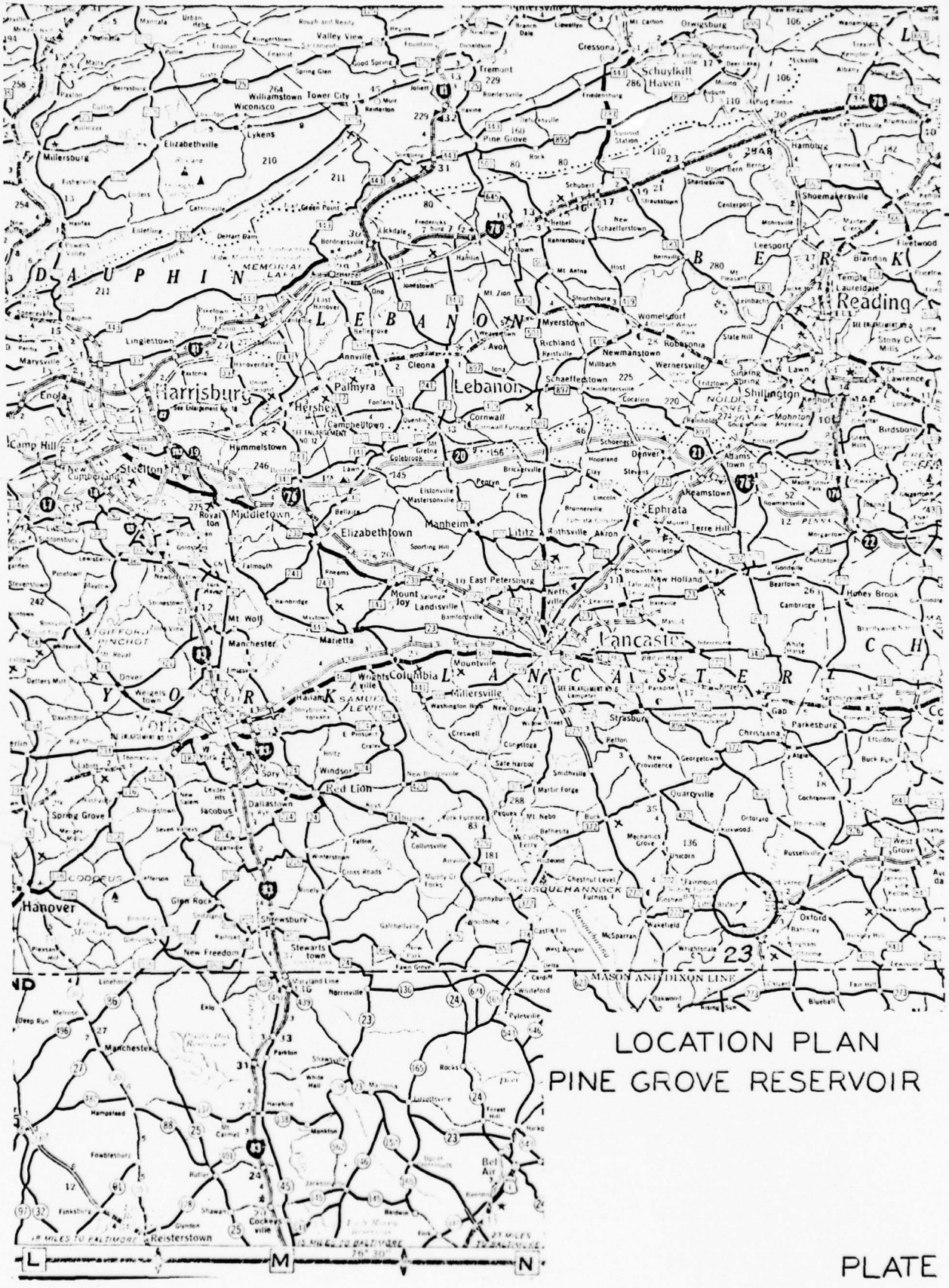
1000 0 1000 2000 3000 4000 5000 6000 7000 FEET

1 .5 0 1 KILOMETER

CONTOUR INTERVAL 20 FEET
DOTTED LINES REPRESENT 10-FOOT CONTOURS
DATUM IS MEAN SEA LEVEL

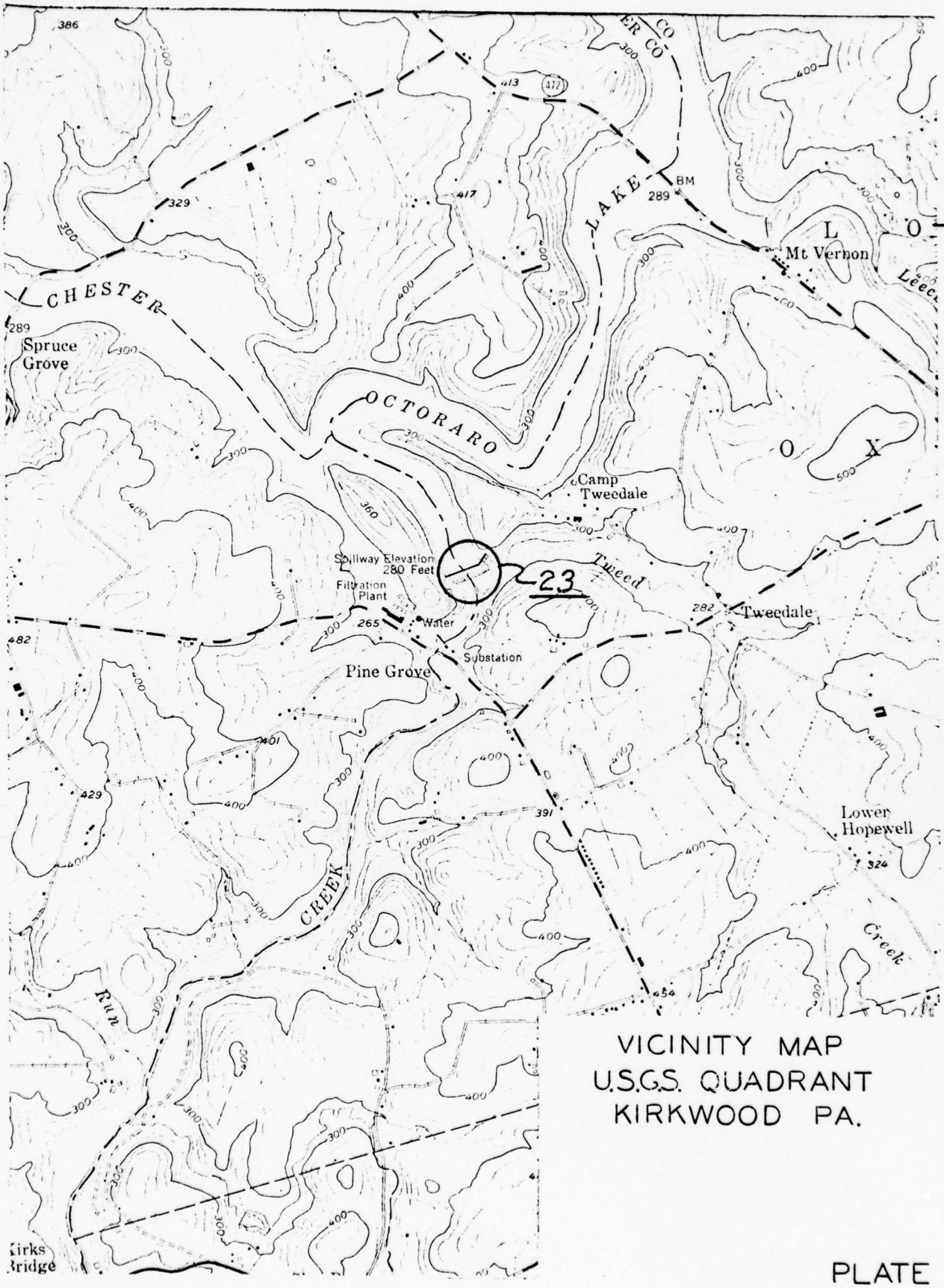
APPENDIX D

LOCATION, PHOTOGRAPHS & DESIGN DRAWINGS



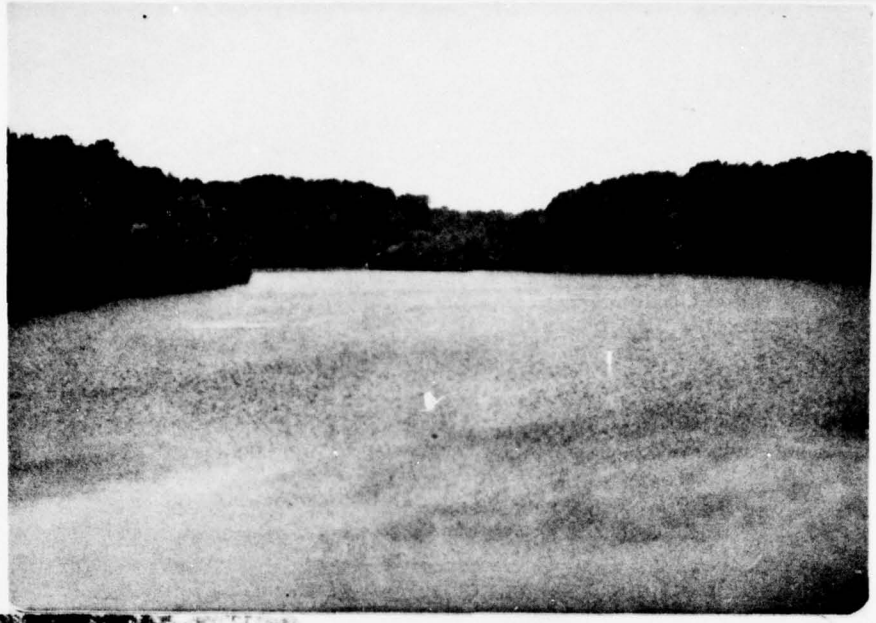
LOCATION PLAN
PINE GROVE RESERVOIR

PLATE I

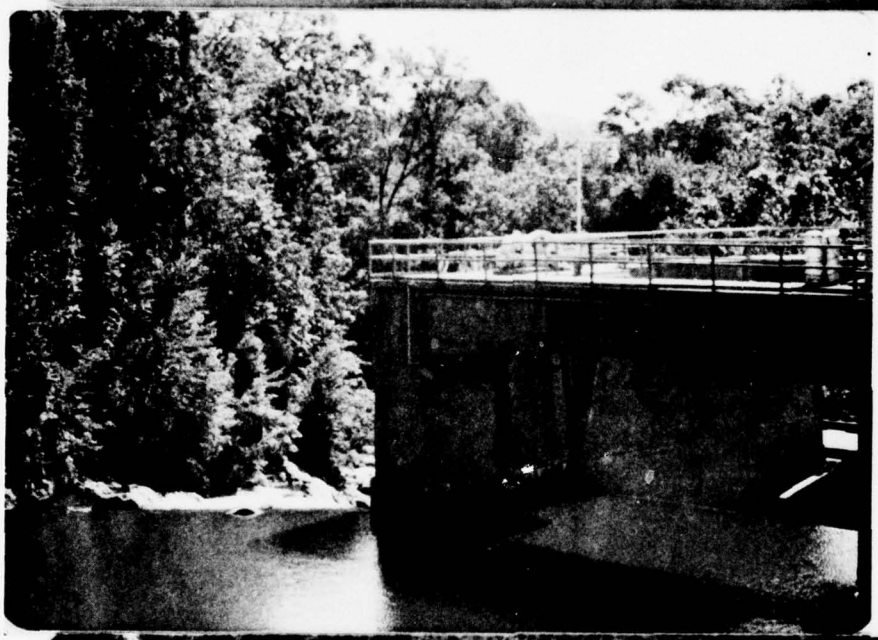


VICINITY MAP
U.S.G.S. QUADRANT
KIRKWOOD PA.

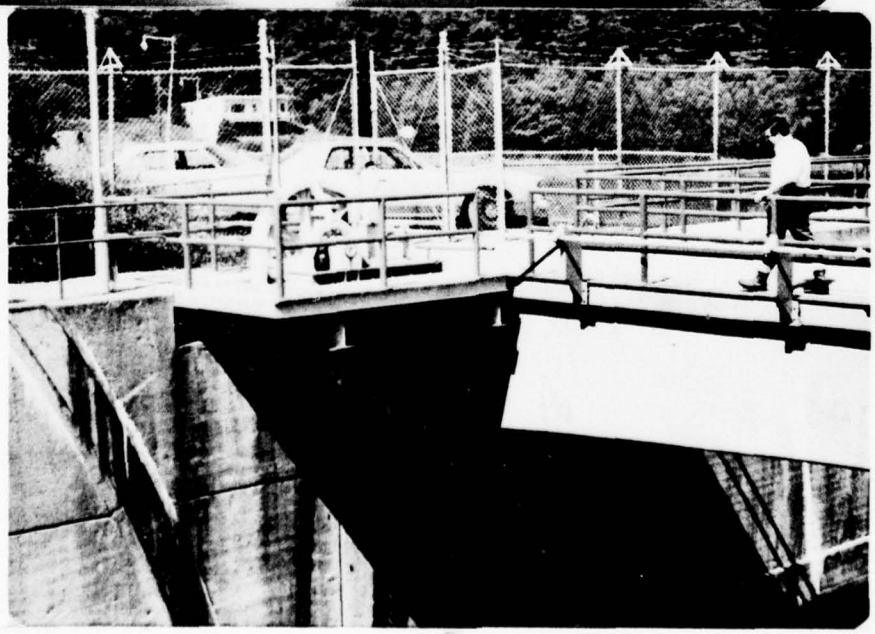
PLATE II



Reservoir



Spillway and
Tainter Gate



Chain of
Tainter Gate

PLATE III

Right
Tainter Gates

Downstream
View of Gates

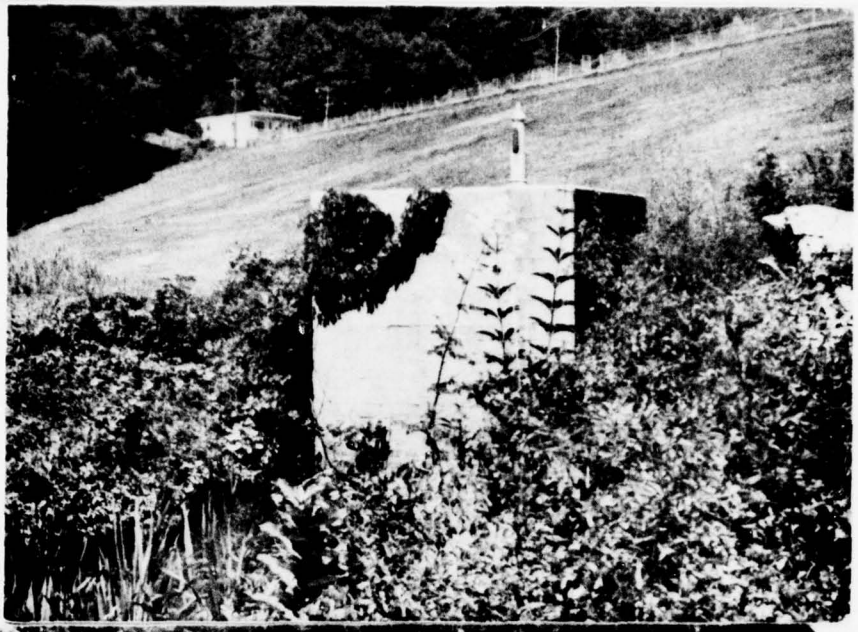
Spillway

PLATE IV

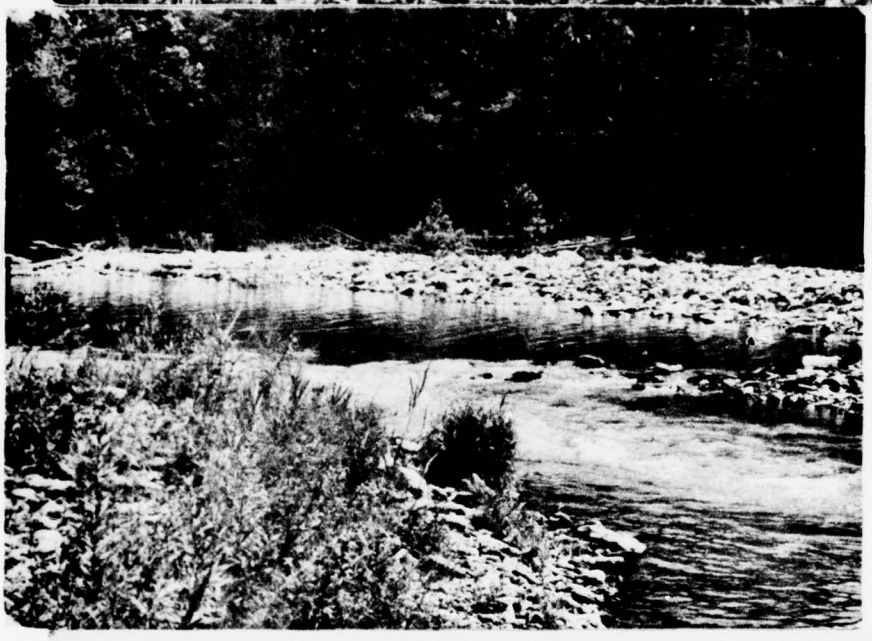
Spillway Chute

Downstream Slope

PLATE V



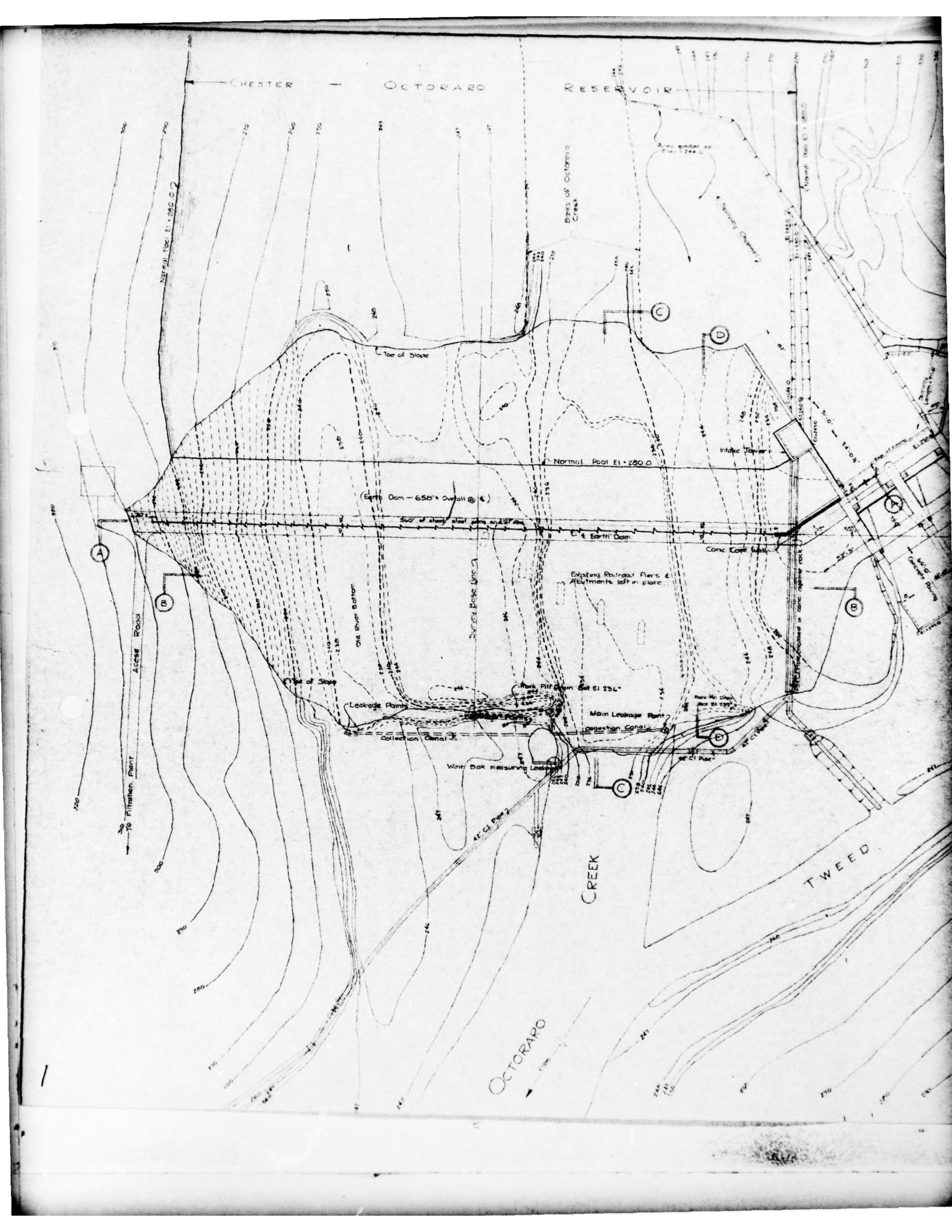
Conduit Outlet

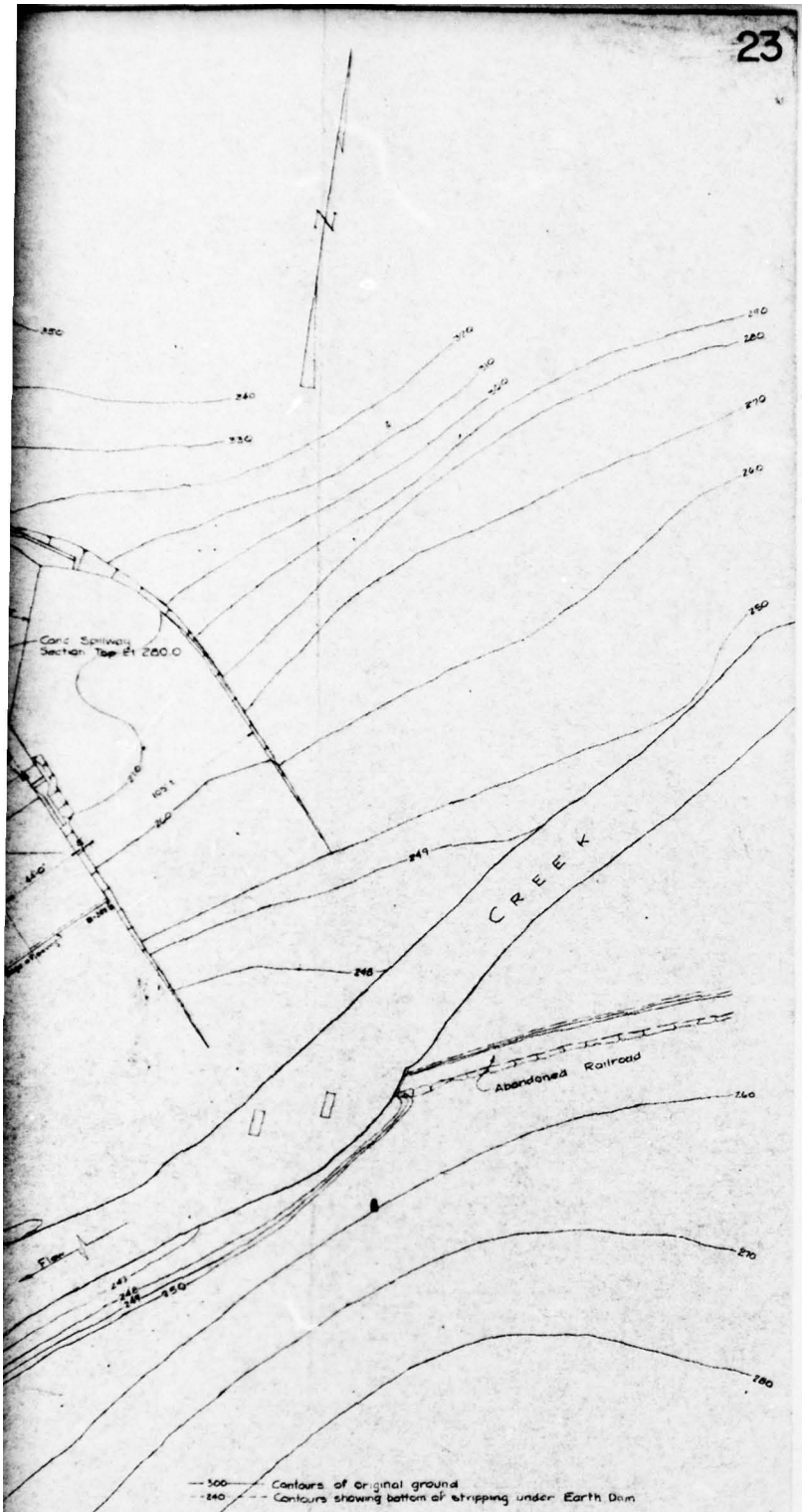


Downstream
Channel

Downstream
Channel

PLATE VI


CHESTER — OCTORARO RESERVOIR
Normal Pool El. 280.0
Toe of Slope
Banks of Octorara Creek
Intake Tower
(Earth Dam — 650'± Overall @ ℄)
360' of sheet steel piling on 2:1 slope
℄ Earth Dam
Conc Knee Wall
Existing Railroad Piers & Abutments left in place
Old River Bottom
Survey Base Line
Toe of Slope
Leakage Points
Collection Canal
Weir Box measuring Leakage
Main Leakage Point
Junction Canal
42" CI Pipe
To Pittsburgh Plant
Access Road
OCTORARO CREEK
TWEED



—500— Contours of original ground
-240- - - Contours showing bottom of stripping under Earth Dam

PLATE VII

CHESTER MUNICIPAL AUTHORITY
CHESTER, PA.

SCALE 1" = 40'

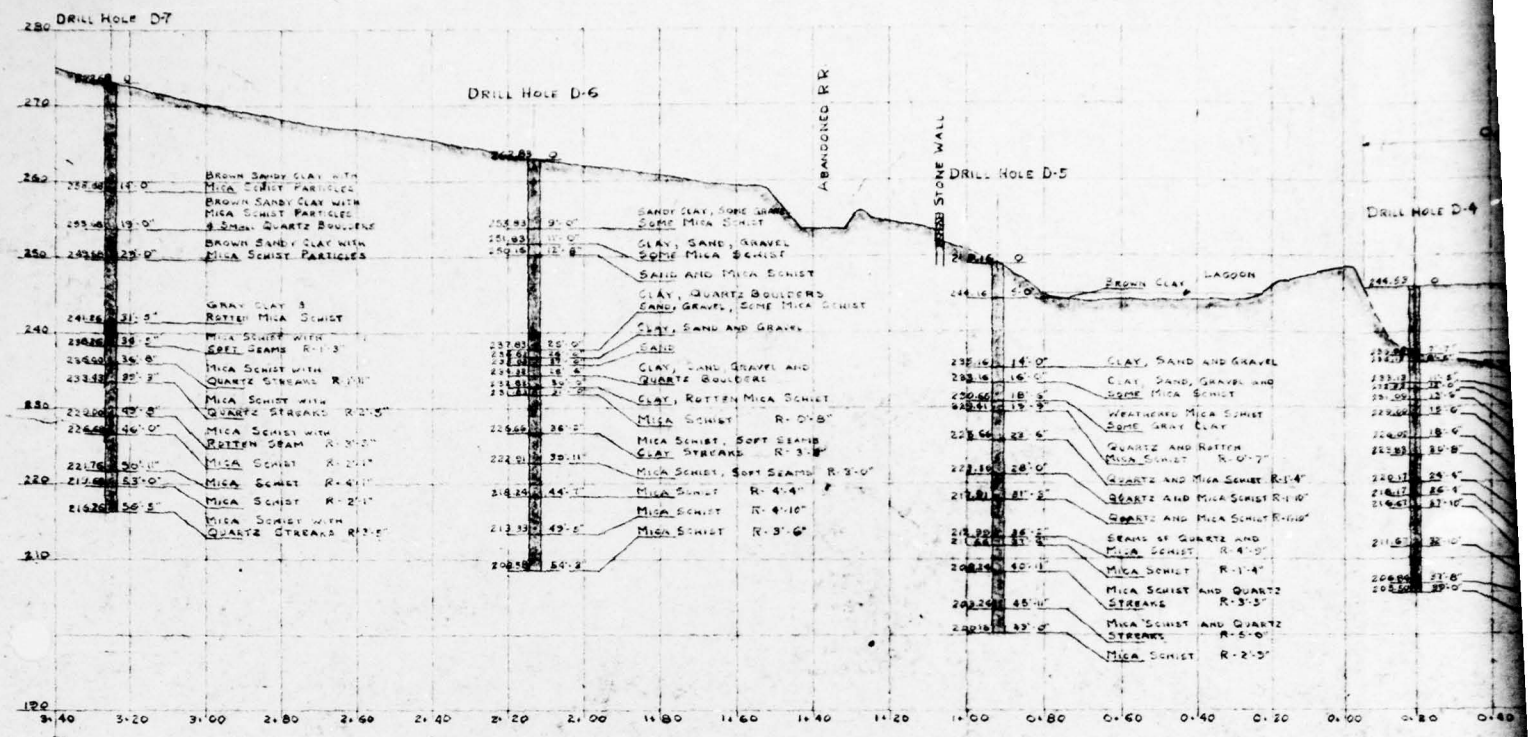
REVISIONS

CHESTER-OCTORARO RESERVOIR
ALONG
OCTORARO CREEK
GENERAL RECORD PLAN

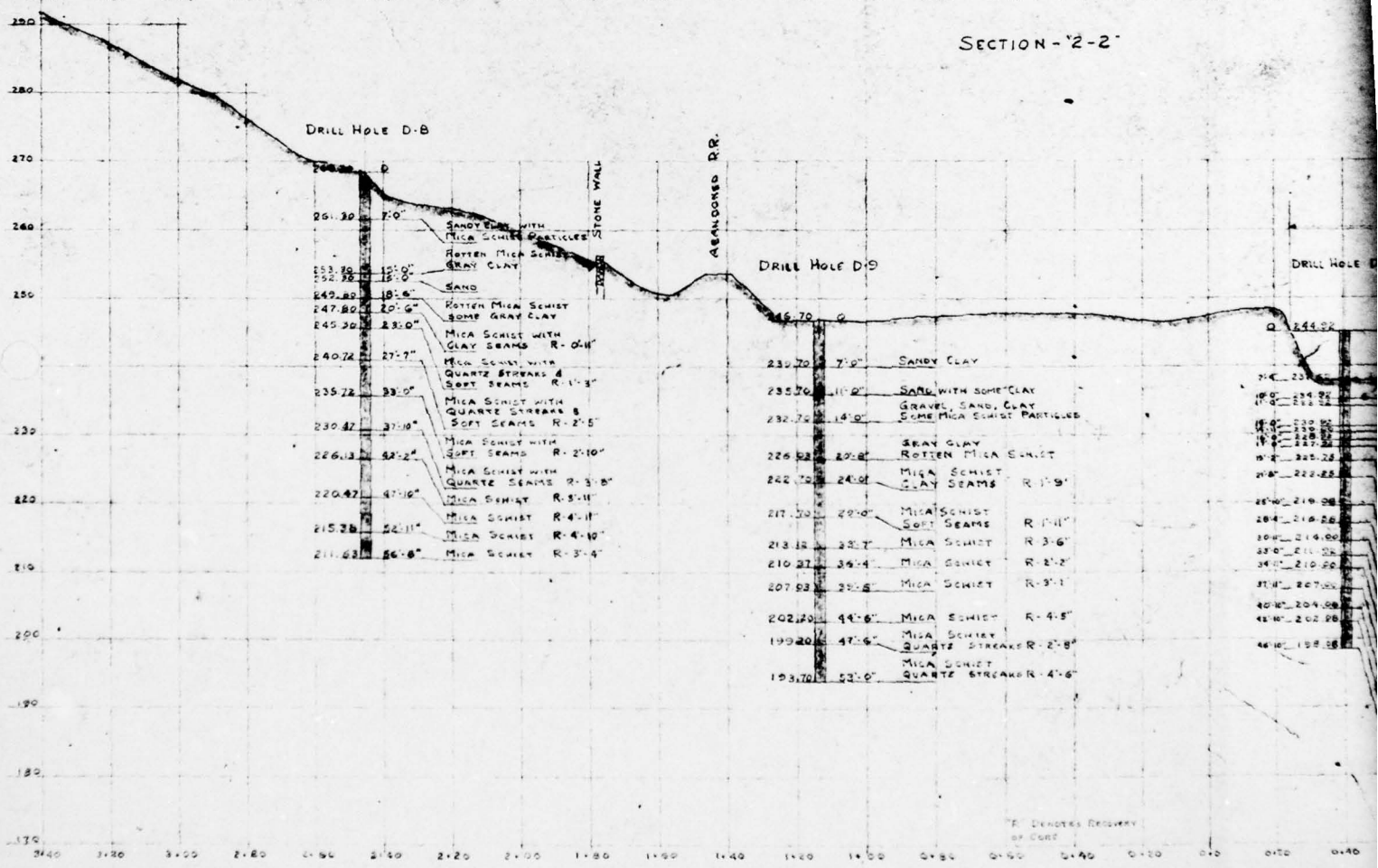
ALBRIGHT & FRIEL, INC.
CONSULTING ENGINEERS
PHILADELPHIA, PA.

DRAWN BY	TRACED BY	APPROVED	DATE
DKW	AAE	Francis J. Friel	APRIL 7, 1952
TRACED BY			PLAN NUMBER
DKW			46078-6R

REGISTERED PROFESSIONAL ENGINEER

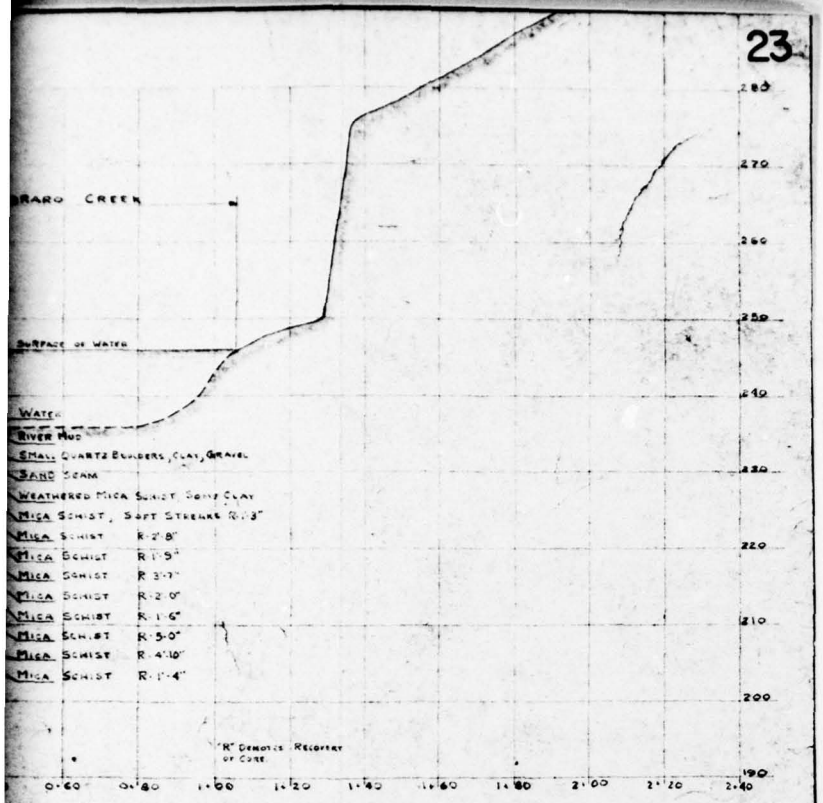


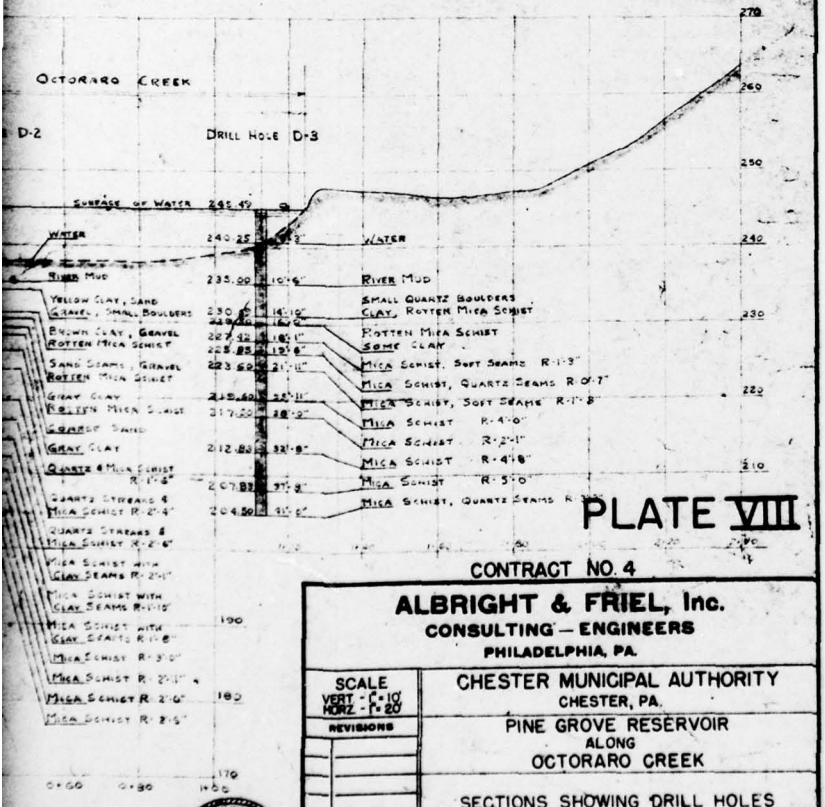
SECTION - "2-2"



SECTION - "1-1"

RECORD





PLAN

PLATE VIII

CONTRACT NO. 4

ALBRIGHT & FRIEL, Inc.
CONSULTING — ENGINEERS
PHILADELPHIA, PA.

SCALE
VERT - 1" = 10'
HORZ - 1" = 20'

REVISIONS

CHESTER MUNICIPAL AUTHORITY
CHESTER, PA.

PINE GROVE RESERVOIR
ALONG
OCTORARO CREEK

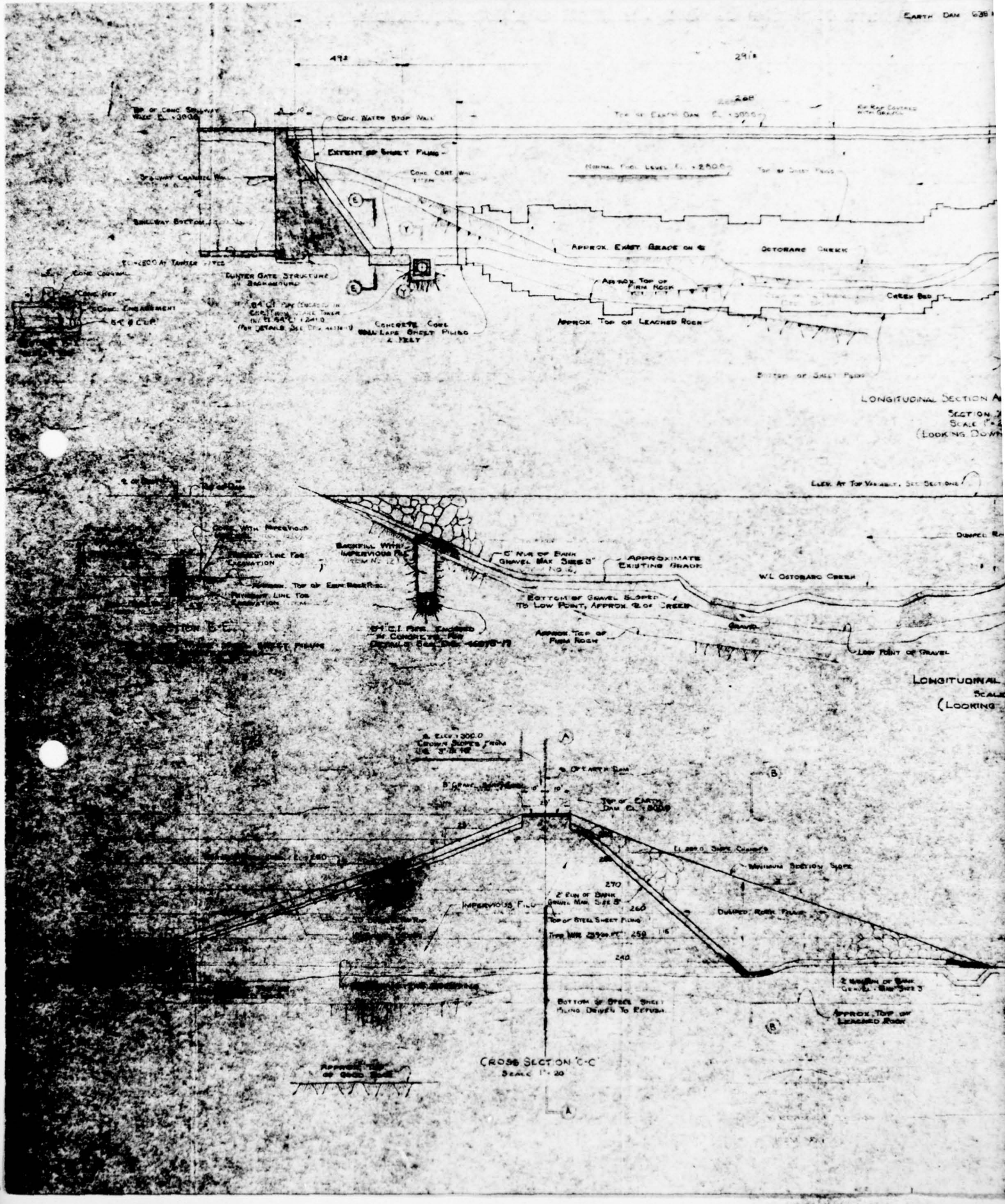
SECTIONS SHOWING DRILL HOLES

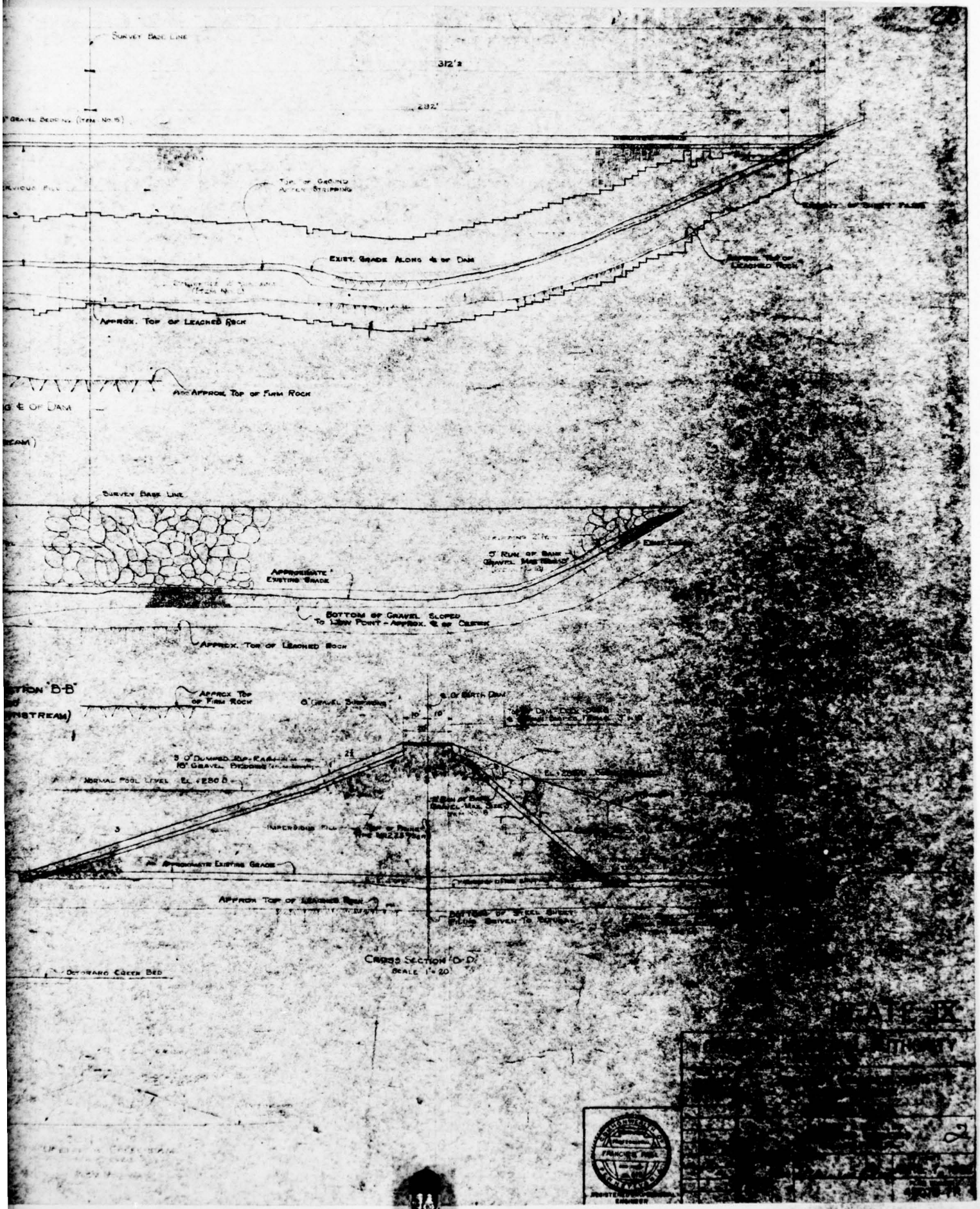
DRAWN BY F.A.F.
TRACED BY F.A.F.
APPROVED
Francis S. Friel
REGISTERED PROFESSIONAL ENGINEER

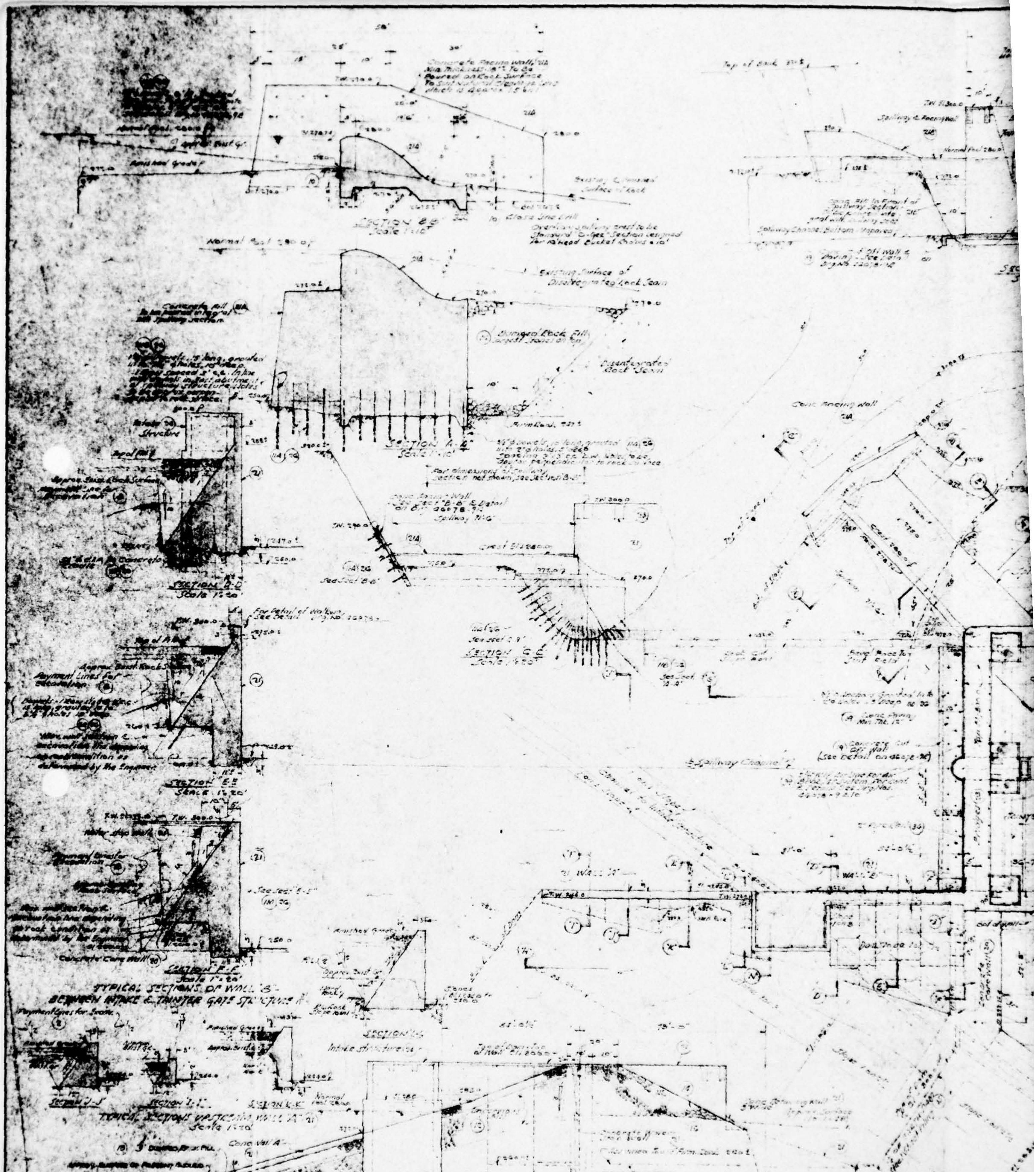
DATE
JULY 24, 1947

PLAN NUMBER
2 46078-4

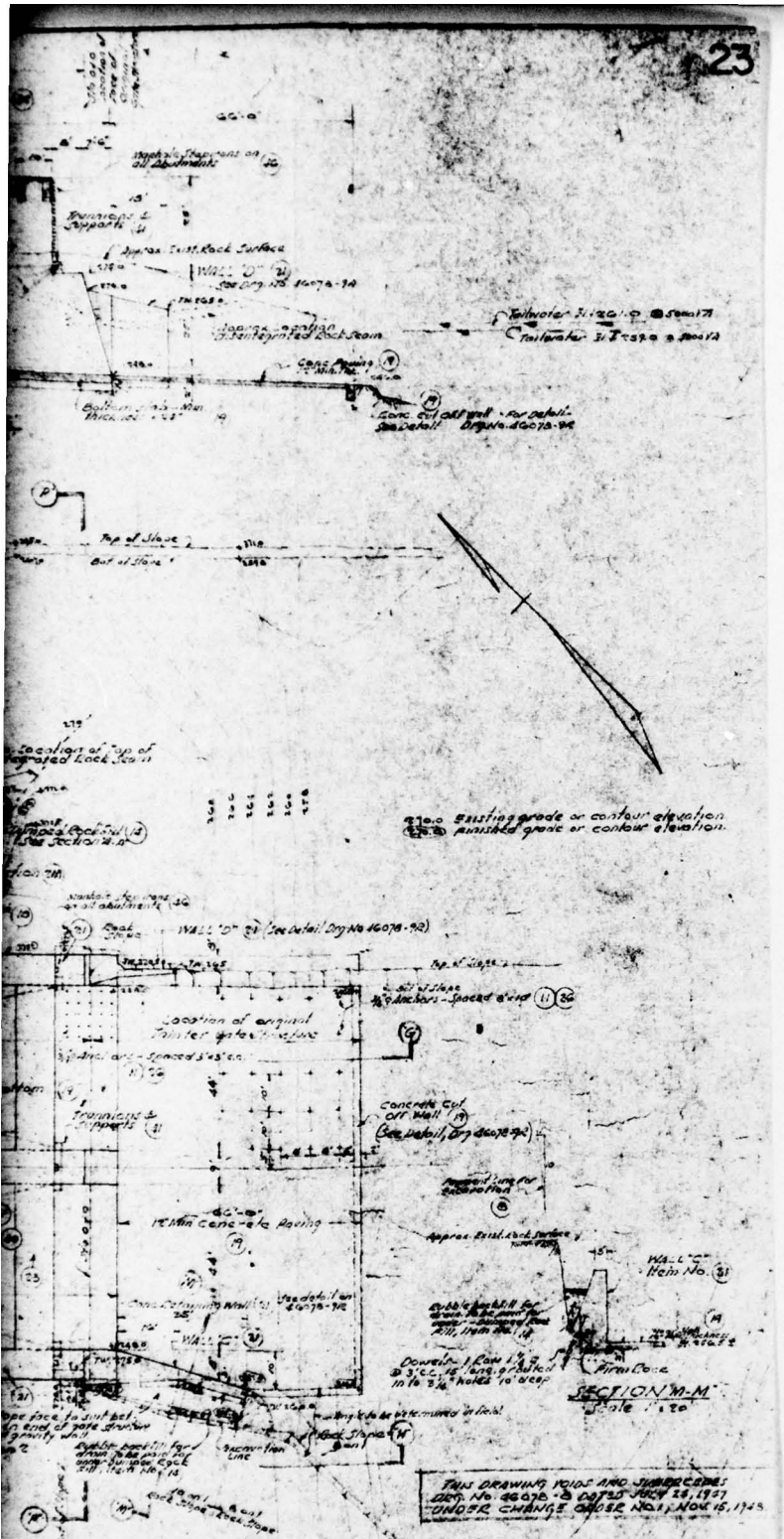
COMMONWEALTH OF PENNSYLVANIA
REGISTERED
FRANCIS S. FRIEL
No. 619


EARTH DAM
Conc. Water Stop Wall
Extent of Sheet Piling
Conc. Cut-off Wall
Normal Pool Level El. +280.0
Top of Sheet Piling
Approx. Ex'st. Grade on ℄
Ostorabe Creek
Approx. Top of Firm Rock
Creek Bed
Approx. Top of Leached Rock
Bottom of Sheet Piling
Outlet Gate Structure in Background
Concrete Core Wall Laps Sheet Piling & Key
LONGITUDINAL SECTION A
Scale
(Looking Down
Elev. At Top As Built, See Section One
Backfill With Impervious Fill
Approximate Existing Grade
W.L. Ostorabe Creek
Bottom of Gravel Slope To Low Point, Approx. El. of Creek
Approx. Top of Firm Rock
Low Point of Gravel
LONGITUDINAL
Scale
(Looking
Top of Earth Dam El. 300.0
Impervious Fill
Top of Steel Sheet Piling
Bottom of Steel Sheet Piling Driven To Refusal
Approx. Top of Leached Rock
CROSS SECTION C-C
Scale 1" = 20


Survey Base Line
312'±
282'
Top of Ground After Stripping
Exist. Grade Along ℄ of Dam
Approx. Top of Leached Rock
Approx. Top of Firm Rock
Survey Base Line
Approximate Existing Grade
Bottom of Gravel Slopes To Low Point – Approx. ℄ of Outlet
Approx. Top of Leached Rock
Approx Top of Firm Rock
Normal Pool Level El. 280.0
Approximate Existing Grade
Approx Top of Leached Rock
Cross Section 'D-D'
Scale 1"=20'
Downward Creek Bed



SECTION B-B
SECTION A-A
Existing Surface of Disintegrated Rock Seam
Dumped Rock Fill
Disintegrated Rock Seam
Conc. Facing Wall
SECTION C-C
SECTION D-D
Scale 1"=20'
SECTION E-E
Scale 1"=20'
SECTION F-F
Scale 1"=20'
TYPICAL SECTIONS OF WALL "B"
BETWEEN INTAKE & TAINTER GATE STRUCTURE
SECTION G-G
Intake Structure
SECTION H-H
TYPICAL SECTIONS UPSTREAM WALL "A"
Wall "A"
Wall "B"
Spillway Channel
Conc. Wall "A"
Channel Bot.
Bot. of Wall
Concrete Core Wall
Finished Grade
Normal Pool 280.0



THIS DRAWING VOIDS AND SUPERCEDES DRG. NO. 46078-B DATED JULY 28, 1947 UNDER CHANGE ORDER NO. 1, NOV. 15, 1948

PLATE X

PLAN
Scale 1"=20'

RECORD PLAN

CHESTER MUNICIPAL AUTHORITY
CHESTER, PENNSYLVANIA

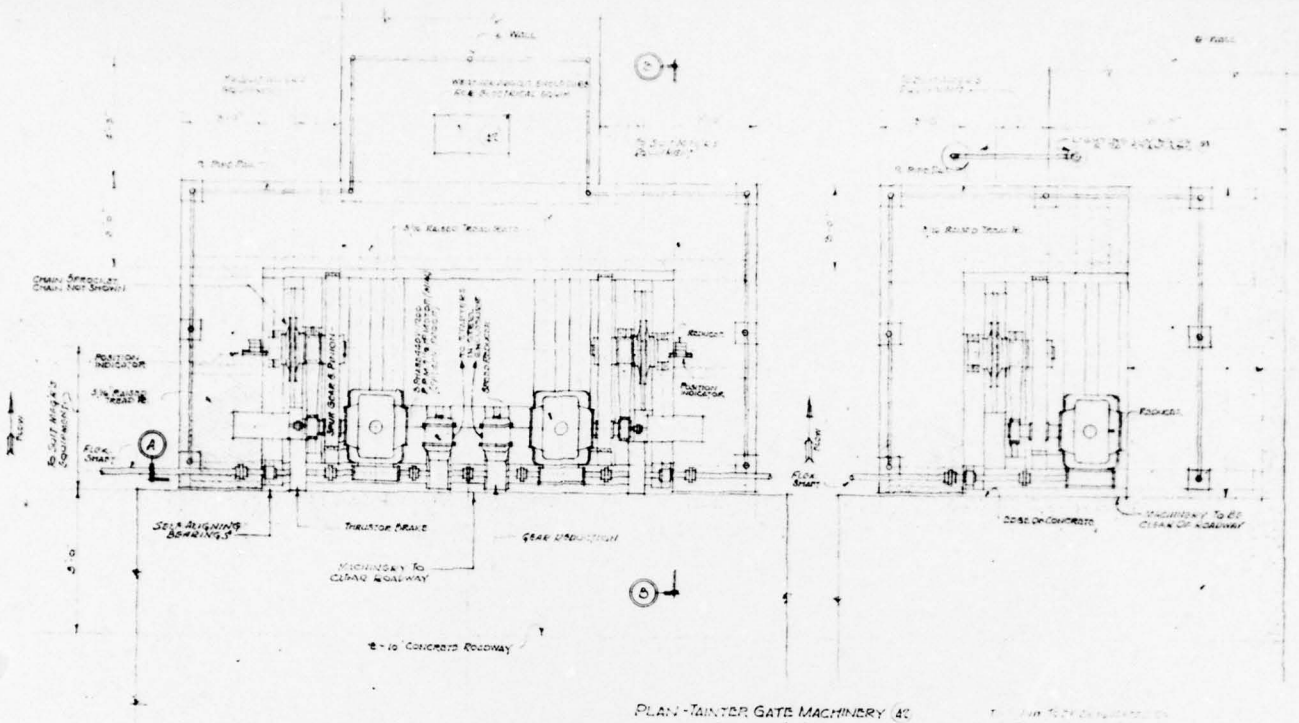
PINE GROVE RESERVOIR
ALONG OCTORARO CREEK
REVISED PLAN & SECTIONS
OF CHANNEL SPILLWAY

ALBRIGHT & FRIEL, INC.
CONSULTING ENGINEERS
PHILADELPHIA, PA.

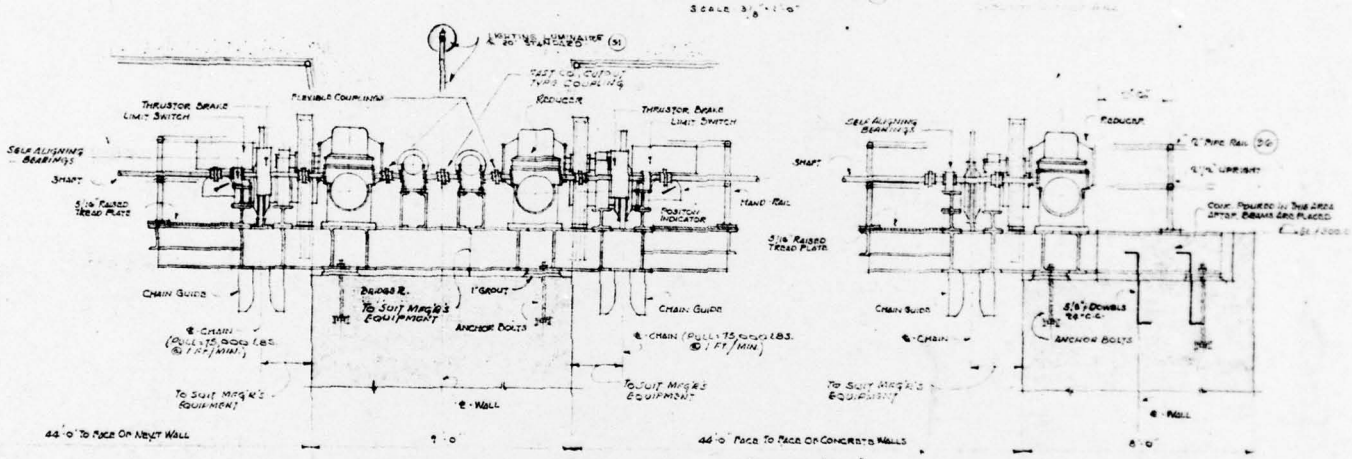
SCALE AS NOTED

DATE NOV. 15, 1948

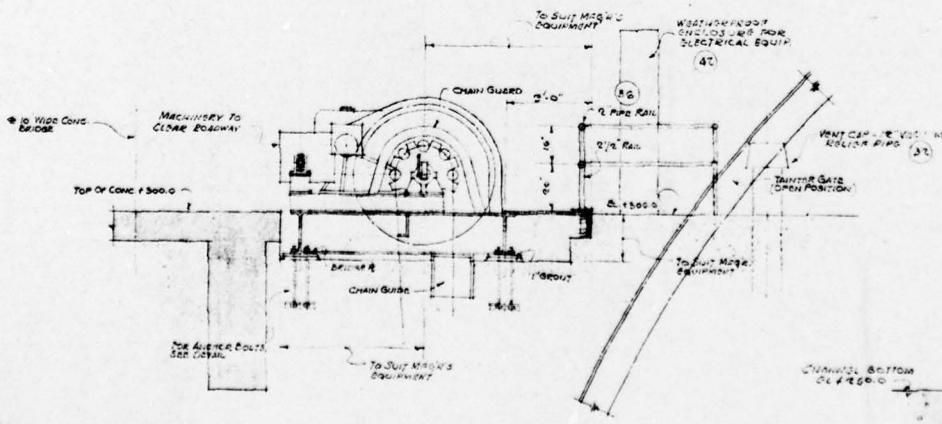
PLAN NUMBER 46078-8R



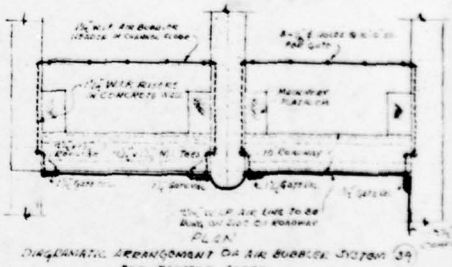
PLAN - TAINTER GATE MACHINERY (42)
SCALE 3/8" = 1'-0"



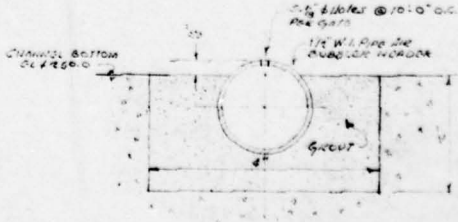
SECTION "A-A"
SCALE 3/8" = 1'-0"



SECTION "B-B"
SCALE 3/8" = 1'-0"



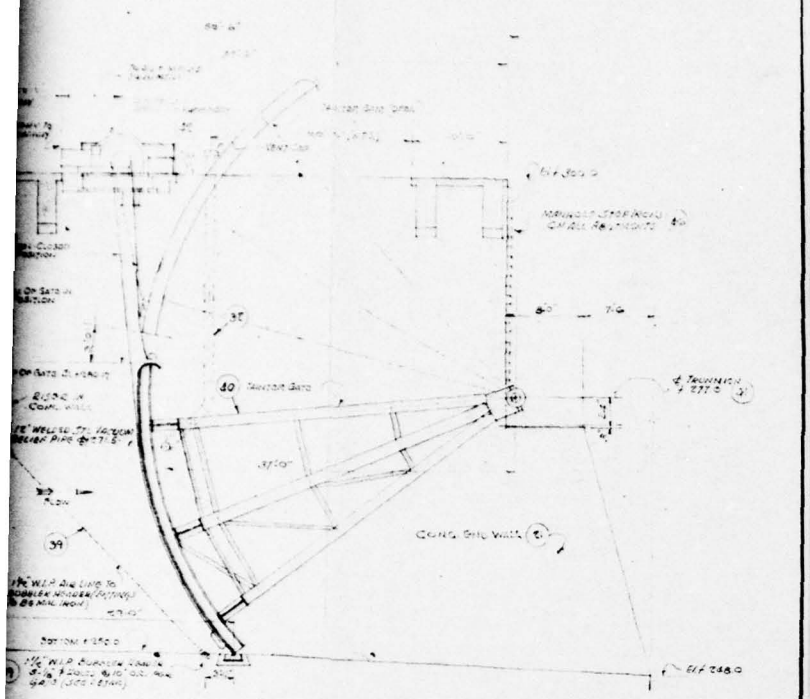
DIAGRAMATIC ARRANGEMENT OF AIR BUBBLER SYSTEM (39) FOR TAINTER GATES
PLAN



DETAIL OF AIR BUBBLER HEADER (39)
SCALE 3/4" = 1'

Handrails
Tainter Gates
Tainter Gate Operating Machinery & Supports
17" Vacuum Breaker
Air Bubbler System

RECOR



SECTION SHOWING TAINTER GATE & OPERATING MACHINERY
SCALE: 1/8" = 1'-0"

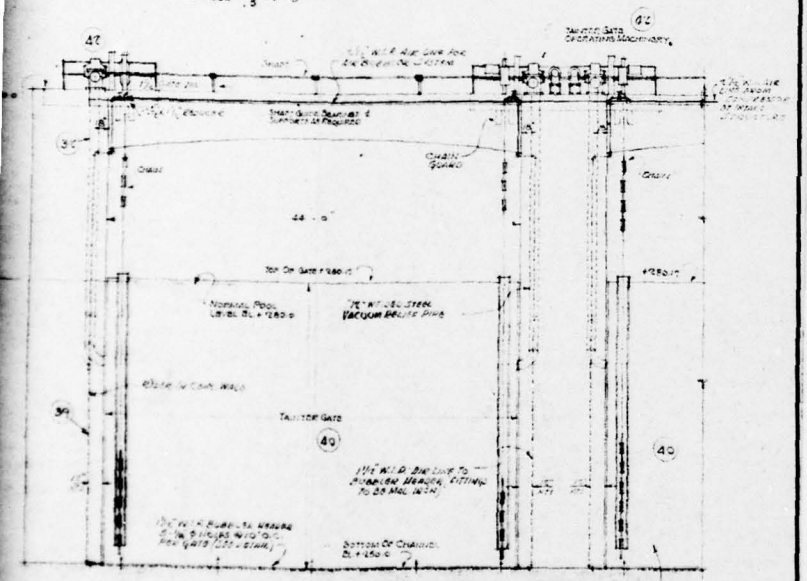


PLATE XI

ELEVATION LOOKING DOWNSTREAM
SCALE: 1/8" = 1'-0"

NOTE:- THE BUBBLER SYSTEM (39) AND VACUUM RELIEF PIPING (42) FOR THIS GATE, TO BE SIMILIAR AS SHOWN FOR OPPOSITE GATE.

CONTRACTS NO. 2, 3 AND 4

ALBRIGHT & FRIEL, Inc.
CONSULTING — ENGINEERS
PHILADELPHIA, PA.

SCALE AS NOTED	CHESTER MUNICIPAL AUTHORITY CHESTER, PA.
REVISIONS	PINE GROVE RESERVOIR ALONG OCTORARO CREEK
	TAINTER GATE GENERAL DETAILS
DRAWN BY P.B.A. / CHECKED BY S.B. / APPROVED	DATE JULY 24, 1947
TRACED BY P.B.A. / REGISTERED PROFESSIONAL ENGINEER	PLAN NUMBER 46078-12

APPENDIX E

TYPICAL OPERATION RECORD
AND
SEEPAGE MONITORING RECORD

CHESTER WATER AUTHORITY

OCTORARO RESERVOIR OPERATION

Date: June 1972

DAY	RESERVOIR ELEV. FT. INCREASE	RESERVOIR CAPACITY MILLION GALLONS	RESERVOIR [illegible]	RESERVOIR LOSS MGD	RAW METER FLOW MGD	SPILLWAY FLOW MGD	TOTAL FLOW MGD	LOWER DAM [illegible]	LOWER DAM FLOW MGD	LOWER DAM GATES Open+ Closed-	[illegible]	REMARKS
1	+1.25				2873			18.84		+		
2	+0.95				2838			15.85		+		
3	+0.58				2776			15.14		+		
4	+0.58				2564			14.24		+		
5	+1.66				2838			21.13		+		
6	+0.79				2771			16.09		+		
7	+0.62				2841			15.38		+		
8	+0.58				2804			15.09		+		
9	+0.46				2802			14.84		+		
10	+0.42				2816			14.80		+		
11	+0.42				2805			14.65		+		
12	+0.32				2856			14.54		+		
13	+0.42				2838			14.52		+		
14	+0.55				2807			15.32		+		
15	+0.58				2860			15.23		+		
16	+0.50				2840			14.88		+		
17	+0.67				2810			15.50		+		
18	+0.58				2536			15.08		+		
19	+0.54				2505			15.00		+		
20	+0.54				2850			15.08		+		
21	+0.50				2816			14.84		+		
22	+2.50				2853			25.50		+		
23	+1.37				2805			24.35		-		
24	+1.41				2711			Out of calibration		-		
25	+1.24				2567			Out of calibration		-		
26	+1.08				2709			19.00		-		
27	+1.00				2617			17.50		-		
28	+0.91				2991			17.37		-		
29	+0.87				3082			17.21		-		
30	+1.00				2815			17.83		-		

CHESTER WATER AUTHORITY

Month of June, 1977

Date	Lake Level	Lower Dam Weir	Upper Dam Weir	Turb.	Dam Piezometers #1	#2	#3
1	+0.60'	12.2"					
2	+0.58'	12"					
3	+0.36'	12"					
4	+0.46'	13.85"					
5	+0.55'	12.6"	1 1/2"	1.6	13"	21"	24 1/4"
6	+0.50'	12.35"					
7	+0.56'	12.2"					
8	+0.52'	12.35"					
9	+0.49'	12.4"					
10	+0.45'	12.1"					
11	+0.40'	11.6"					
12	+0.40'	11.45"	1 1/4"	.83	10"	25"	26 3/4"
13	+0.46'	11.8"					
14	+0.45'	11.6"					
15	+0.35'	11.3"					
16	+0.34'	11.3"					
17	+0.42'	11.1"					
18	+0.42'	11.2"					
19	+0.40'	11.10"		2.2			
20	+0.40'	11.19"					
21	+0.38'	10.91"					
22	+1.0'	17.41"					
23	+0.38'	12.75"					
24	+0.42'	11.55"					
25	+0.42'	11.3"					
26	+0.35'	11.00"	1 7/8"	.87	14"	27"	28"
27	+0.32'	17.00"					
28	+0.32'	17."					
29	+0.36'	12.2"					
30	+0.30'	11.2"					
31							

CHESTER WATER AUTHORITY

Month of July, 1978

Date	Lake Level	Lower Dam Weir	Upper Dam Weir	Turb.	Dam Piezometers #1	#2	#3
1	[illegible]	11.2"					
2	[illegible]	10.8"					
3	[illegible]	13.00"	1"±	3.0	12"	[illegible]	[illegible]
4	[illegible]	[illegible]					
5	[illegible]	[illegible]					
6	+0.60'	13"					
7	+0.50'	12.25"					
8	+0.50'	11.9"					
9	+0.45'	11.7"					
10	+0.40'	11.6"	1 1/4"	2.1	17 1/4"	23 1/2"	28"
11	+0.40'	11.55"					
12	+0.35'	11.2"					
13	+0.35'	11.15"					
14							
15							
16							
17							
18							
19							
20							
21							
22							
23							
24							
25							
26							
27							
28							
29							
30							
31							